Study on Efficiency of Plant Carbon Sequestration and Oxygen Release in Ecological Restoration of Expressway Slope

Wang Dan*

38905936@qq.com*

Research Institute of Highway Ministry of Transport Key Laboratory of Environmental Protection Technology on Road Traffic Ministry of Transport, Beijing, 100088, China

Abstract. In order to boost the research on the efficiency of carbon sequestration and oxygen release of plants in the ecological restoration of China's expressways, the project team has carried out many site investigations on the slope, investigated the rock quality of the slope and the status quo of the main green vegetation, investigated and summarized the characteristics of the slope along the entire line of the Molin expressway and the surrounding plants. It includes soil quality, orientation, slope, stability, slope protection type, soil type, plant species and plant community composition, etc. And to the greening unit for the scene of the inquiry. By comparing and selecting the suitable seedling varieties in the ecological environment restoration of expressway slope, this paper provides a certain reference for the implementation of similar projects in the future, in order to achieve better results in the future implementation of projects.

Keywords: Carbon sequestration and oxygen release; Ecological restoration; Plant species; Expressway slope

1. Introduction

After President Xi Jinping proposed the goal of carbon peaking and carbon neutrality at the 75th United Nations General Assembly in September 2020, all industries, from the national decision-making level to the national level, are rapidly recognizing the importance of this goal and developing concrete action plans across the board. All sectors are rapidly recognizing and developing concrete action plans[1]. Highway is a representative infrastructure project in the transportation industry. Since the 1990s, China's highways have developed rapidly, and by the end of 2020, the total mileage of China's highways will be about 161,000 km, which is the first in the world [2]. The Ministry of Transportation and Communications (MOTC) issued the "Guidelines for Accelerating the Development of Green, Circular, and Low-carbon Transportation" in 2013. Low-Carbon Transportation Development" issued by the Ministry of Transport as early as 2013, emphasizing the construction and research and development of green, cyclic and low-carbon transportation technologies. Transportation technology construction and research and development, and promoting greening and beautification projects. The Ministry of Transportation issued the "Guidelines for Accelerating the Development of Green, Circular and Low-Carbon Transportation" in 2013, emphasizing the construction and research and development of green, circular and low-carbon transportation technologies, and the promotion

IDEE 2023, November 24-26, Zhengzhou, People's Republic of China

DOI 10.4108/eai.24-11-2023.2343446

of greening and beautification projects.

At present, the study of "dual-carbon" of highways has been carried out in various fields, especially in the fields of service areas, toll stations, interchanges and hubs. In the study of carbon sequestration on highways, Li Sitao et al[3] pointed out that the construction of low carbon ecological service areas on highways should be combined with the natural geographic characteristics and climatic conditions, and that new technologies, new materials, green plants, and green energy should be fully utilized in the whole process of planning, designing, and construction, as well as in the whole process of operation to implement "carbon sequestration and oxygen release". green plants, and green energy, and implement the "carbon offset" measures of "carbon sequestration and oxygen release" and "energy saving and emission reduction" to realize carbon offset. offsetting measures to realize the balance between carbon emission and carbon offsetting, and to achieve the goal of building a low-carbon ecological service area. The goal of building a low-carbon ecological service area is achieved by realizing a balance between carbon emissions and carbon offsets. Meanwhile, Xu Ming et al. At the same time, Xu et al[4] pointed out that optimizing the allocation of high carbon sequestering green space in service areas and combining carbon emission reduction can help to achieve the goal of carbon neutral service areas. Meanwhile, Han Zizhu[5], relying on the greening design of Ankang West Toll Station, analyzing the design from the aspects of ecological restoration, landscape construction, energy saving and low carbon, The greening design of Ankang West Toll Station was analyzed, and the design should be comprehensively considered in terms of ecological restoration, landscape construction, energy saving and low carbon emission, Grass, rattan and trees are used to strengthen the beautification effect and ecological effect of the toll station, so that the greening of the toll station due to the highway construction can be improved. effect, in order to be able to the environmental damage caused by the construction of highway. The only way to restore the environmental damage caused by the construction of highway. Jia Tong Group[6] relies on the highway in 8 interchanges and junctions based on the highway. Through monitoring and measurement, the average annual net carbon volume of the project is about 2,294 tons, and the economic benefit of carbon sequestration trading is about RMB 4.4 million. Through monitoring and measurement, it is concluded that the average annual net carbon volume of the project is about 2,294 tons, and the economic benefit of carbon sequestration is about RMB 44,000 yuan, and the value-added benefit is about 4 million yuan. The economic benefit of carbon sequestration transaction is about RMB 44,000 yuan, and the value-added benefit is about 4 million yuan. Overall On the whole, the research on highway carbon sequestration has just started, especially the concept of carbon sequestration in highway greening project[7]. In general, the research on highway carbon sequestration has just started, especially the concept of carbon sequestration in highway greening projects is relatively vague.

Therefore, it is necessary to master the Therefore, it is very necessary to grasp the technology of highway slope vegetation carbon sequestration and the assessment of the value. It is imperative to carry out research on highway slope vegetation carbon sequestration.

2. Selection of Experimental Slopes and Problem Analysis

2.1 Criteria for Selection of Typical Slopes

The project team has repeatedly conducted field studies on the slopes of the project, investigating the current status of the slope rock quality and primary greenery vegetation. The research summarizes the characteristics of the slopes and surrounding vegetation along the entire Molin expressway, including the nature of the slope soil, orientation, slope, stability, slope protection type, soil type, types of plants, and composition of plant communities. Queries about the on-site situation were also made to the greening unit.

The research found that the Molin expressway is located between the Ailao and Wuliang mountain ranges. The stratum lithology is mainly sedimentary rock, with the Mesozoic Triassic (T) being mudstone, limestone, and shale, and the Jurassic (J) mainly being purple-red mudstone, sandstone, and conglomerate. The typical slope types along the entire Molin expressway can mainly be divided into: weathered granite slopes, carbonaceous shale slopes, and sand-mudstone slopes. In addition, there are soil slopes and soil-rock mixed slopes. Granite areas in the southern part of China cover a total area of 239,000 km^2, mainly distributed in Guangdong, Fujian, and the southeastern part of the west, the southern part of Hunan and Jiangxi in the Yangtze River basin, the eastern and southwestern parts of Anhui and Hubei, and parts of Sichuan province[8]. Therefore, choosing granite slopes as the treatment target for the Molin expressway has a demonstrative significance in the slope protection process of similar projects across the country.

The research found that the Matai service area is an important node on the Molin expressway. Currently, there are excavated granite slopes in the area. According to the overall requirements for building beautiful service areas in Yunnan province, the overall landscape of the Matai service area has been greatly enhanced[9]. However, the ecological protection of the excavated slopes remains a technical problem yet to be solved. Therefore, the project team chose to conduct experimental research based on the granite slopes in the Matai service area, aiming to explore a scientifically effective protection and maintenance strategy for the granite slopes in similar projects.

2.2 Slope Overview

As shown in Figure 1, the slope is located within the Matai service area, on the right side of the protection slope from AK0+115.27 to AK0+206.82 on ramp A, with high requirements for landscape greening. The slope is a 5-level slope of completely weathered and strongly weathered mixed granite. Among them, the first-level slope uses anchor rod frame beams, with C32 steel bars as the anchor rods. The second, third, and fourth level slopes use anchor cable frame beams, with 4 bundles of As/15.2mm steel strands as the anchor cables. The fifth-level slope uses an arched grid for slope protection.

Figure 1 Granite slope of Matai service area

Strongly weathered granite is sandy and gravelly[10], with poor water retention and weak erosion resistance. It is prone to severe erosion, which can easily lead to mountain collapses and landslides[11]. Instability and collapse can easily occur during the construction process, and even after many years of operation, some slopes still experience landslides, resulting in serious soil erosion, damaging the foundation of the highway, nearby land, and water flow, and causing serious impact on the local environment and traffic safety. Features of strongly weathered granite slopes on expressways: Firstly, the topsoil is completely destroyed, and most of the newly excavated slope is subsoil or rock, without soil or with thin soil, lacking the nutrients and water needed to sustain plants, making it even difficult to anchor plants. Secondly, compared to flat land, the water absorption and retention capacity per unit area of the slope drops significantly as the gradient becomes steeper[12]. Thirdly, different slope orientations can lead to differences in the use of sunlight, water, and temperature by plants[13]. Therefore, the ecological protection of strongly weathered granite slopes on expressways should solve two problems: firstly, how to create a substrate for plant growth, and secondly, how to reasonably choose plants[14].

For this reason, the project team conducted ecological restoration experiments on the slopes of the Matai service area to solve the above problems, providing a reference for the ecological restoration of strongly weathered granite slopes.

2.3 Selection and Habit Analysis of Suitable Greening Species for Slopes

Based on the successful experience of slope greening in Yunnan in the past and the slope quality and environmental characteristics of the experimental slopes on the Molin expressway, the project team conducted suitable species selection for the greening of the Molin expressway slopes. When choosing plants, the aim was to build as much as possible a complex plant community with rich levels, taking into account the short-term, medium-term, and long-term effects of slope greening. At the same time, landscape plants that can reflect seasonal changes were chosen, to achieve the effect of being evergreen in all four seasons, having flowers in all four seasons, being harmonious and natural, and having a positive succession.

Based on the research on the main greening seedlings in the area where the Molin expressway is located, the project team selected a total of 63 commonly used greening plants, including 7 types of trees, 22 types of shrubs, 18 types of turf, 8 types of flowers, and 8 types of vines[15] [16] [17] .

3. Research on the Carbon Sequestration and Oxygen Release Benefits of Greening Plants

3.1 Experimental Materials

The experimental area for this study is located in Kunming, Yunnan Province. Kunming is in the central part of the Yunnan-Guizhou Plateau in southwestern China, between 102°10' to 103°40' east longitude and 24°23' to 26°22' north latitude. The city center is located at 25°02'11" north latitude and 102°42'31" east longitude. Kunming has a North Subtropical low-latitude highland monsoon climate, with long sunshine hours, short frost periods, and an average annual temperature of 15°C. In 2020, the average precipitation in Kunming was 782.0mm, with an average annual sunshine of about 2200 hours and a frost-free period of more than 240 days. The climate is mild, without extreme heat in summer or harsh cold in winter. It's spring-like all year round and has a pleasant climate.

Twenty-five common greening afforestation plants were selected from the Chenggong area of Kunming. Each of the test plants was selected from within the Chenggong campus of the Kunming University of Science and Technology, with consistent environmental, site, and management conditions. All plants were naturally grown, healthy, and free of obvious diseases and pests.

3.2 Experimental Method

3.2.1 Calculation of the net assimilation amount of various plants on the day of measurement by using the simple integral method

The Li-6400 portable photosynthesis meter manufactured by the American Li-Cor company was used. The net photosynthesis rate of the selected tree species was measured every 2 hours from 9:00 to 17:00 each day[1]. For each tree species, 3 plants were selected, and 3 functional leaves from the middle periphery of each plant were measured. The average of 3 measurements was taken. Based on the daily variation curve of the net photosynthesis rate of each tree species, the simple integral method was used to calculate the net assimilation amount of various plants on the day of measurement[18]. The calculation formula is as follows[2].

$$P=\sum_{i=1}^{j} [((P_{i+1}+P_i)/2)\,(t_{i+1}+t_i)3600/1000] \qquad (1)$$

Where: P is the daily total assimilation of the tree species [mmol/(m^2·s)]; P_i is the instantaneous photosynthesis rate of the initial measurement point [μmol/(m^2·s)], P_{i+1} is the instantaneous photosynthesis rate of the next measurement point [μmol/(m^2·s)]; t_i is the instantaneous time of the initial measurement point (hours), t_{i+1} is the time of the next measurement point (hours); j is the number of tests. The dark respiration consumption of plants at night is generally calculated as 20% of the daytime assimilation amount[3]. Therefore, the calculation formula for the net daily carbon fixation amount per unit leaf area is as follows.

$$W_{CO2}=P(1-0.2)(44/1\,000) \qquad (2)$$

Where: Here, W_{CO2} is the daily fixed amount of CO_2 for the tree species [g/(m^2·d)], and 44 is the molar mass of CO_2. According to the reaction equation of photosynthesis, $CO_2 + 4H_2O \rightarrow CH_2O + 3H_2O + O_2$, the amount of oxygen released by the plant on the day of measurement can be calculated. The formula is as follows[4].

$$W_{O2}=P(1-0.2)(32/1\ 000) \quad (3)$$

Where: W_{O2} is the daily amount of O_2 released [$g/(m^2 \cdot d)$], and 32 is the molar mass of O_2.

The daily change graph of the net photosynthesis rate of each tree species was plotted by using Excel drawing software to analyze the regularity of the data.

3.2.2 Estimation of the Carbon Sequestration Capacity of Garden Tree Species through the Leaf Area Index

Based on the leaf area index of a single tree, a formula for the ecological benefit estimation model of urban garden trees with morphological characteristic indicators as independent variables is derived[4]. The general form of the equation is:

$$Y = ab \quad (4)$$

$$b= \pi cd^2/4 \quad (5)$$

In equations (4) and (5), Y is the daily carbon sequestration and oxygen release value of a single plant (g), a is the daily carbon sequestration and oxygen release value per unit leaf area (g/m^2), b is the total leaf surface area of the plant (m^2), c is the leaf area index, and d is the crown width (m). Substitute equation (4) into equation (5) to get:

$$Y = \pi acd^2/4 \quad (6)$$

From equation (6), it can be seen that as the leaf area index c increases, the carbon sequestration capacity of the tree also increases under certain crown width. The data obtained by this method of estimating the carbon sequestration amount of garden tree species through the leaf area index is still the daily carbon sequestration amount of a single tree species.

3.2.3 Estimation of Plant Carbon Sequestration Capacity through Biomass

Fang Jingyun et al. used the biomass measurement data in the literature and the forest resource survey data in China, and proposed the use of biomass conversion factor (*BEF*) method to establish the relationship between biomass and stock volume[4]. The ratio of stand biomass to timber volume (that is, *BEF*) is not constant. Further research shows that stand volume can be used as a function of the conversion factor to represent the continuous variation of *BEF*. Fang Jingyun et al. use the power exponent function to express the relationship between *BEF* and stand volume (x)[4]:

$$BEF = ax+b \quad (7)$$

When the volume is large, *BEF* tends to the constant value a; when the volume is small, *BEF* is large. This conclusion is consistent with the relevant growth theory of trees. This formula simplifies the calculation of regional forest biomass. It can be represented as a simple linear relationship between biomass and stock volume[4]:

$$B = a+bV \quad (8)$$

In equation (8): a and b are both constants; a is the ratio of trunk wood biomass to total forest biomass, b is the percentage of above-ground or below-ground biomass in the total biomass of the forest; B represents biomass; V represents stock volume.

This method is based on establishing the relationship between biomass and stock volume, so as to estimate the carbon storage of plants[4]. Generally speaking, plants with large stock volumes have large carbon sequestration, and vice versa.

(4) Calculation of Plant Carbon Sequestration Capacity through Productivity

The carbon sequestration formula for vegetation provided in the national forestry industry standard (LY/T1721-2008) "Evaluation Specification for Service Functions of Forest Ecosystems" is[4]:

$$G_{\text{plant carbon sequestration}} = 1.63\, R_{\text{carbon}} A B_{\text{years}} \qquad (9)$$

In equation (9), $G_{\text{plant carbon sequestration}}$ is the annual carbon sequestration of vegetation ($t \cdot a^{-1}$); R_{carbon} is the carbon content in CO_2, which is 27.27%; A is the stand area (hm^2); B_{year} is the net productivity per unit of the stand ($t/hm^2 \cdot a$). This method estimates the carbon sequestration of a forest community in one year. From equation (9), it can be seen that the higher the net productivity per unit of the stand, the greater the carbon sequestration of the community[4].

This paper uses the first method, i.e., the simple integral method, to calculate the net assimilation of various plants on the day of measurement.

4. Results and Analysis

The measurement of plant photosynthesis is influenced by various external environments such as weather, temperature, air humidity, as well as errors caused by instrument use and manual data processing[19]. This study analyzes the plant's carbon sequestration capacity from the perspective of the daily net carbon sequestration of plants.

4.1 Daily Net Carbon Sequestration of Plants

The daily net photosynthetic assimilation of plants refers to the difference between the organic matter produced by plant photosynthesis during the day and the organic matter consumed by respiration at night. The greater the daily net photosynthetic assimilation, the stronger the plant's productivity[4], and the greater the carbon content fixed in the body and the amount of oxygen released into the air. The values of carbon sequestration and oxygen release of various plants are shown in Table 1. From Table 1, it can be seen that the six tree species with the strongest photosynthetic assimilation ability among the measured plants are Chrysopogon aciculatus, Rubusobcordatus, Ivy, Honeysuckle, Fragrant eupatorium herb, and White clover, and the six tree species with the weakest photosynthetic assimilation ability are Morning glory, Cosmos bipinnatus, Boston ivy, Blackberry lily, Cape jasmine, and Chlorophytum comosum 'medio-pictum'. Among them, the Chrysopogon aciculatus with the strongest photosynthetic assimilation ability has a daily net photosynthetic assimilation that is 15.69 times that of the Chlorophytum comosum 'medio-pictum' with the weakest photosynthetic assimilation ability.

According to the calculations of formula (1) and (2), the daily net carbon sequestration of 25 kinds of plants was obtained. As can be seen from Table 1, Chrysopogon aciculatus has the largest net assimilation and daily net carbon sequestration, with a net assimilation of 528.9 $mmol \cdot m^{-2} \cdot s^{-1}$ and a daily net carbon sequestration of 18.62 $g \cdot m^{-2} \cdot d^{-1}$, while the Chlorophytum comosum 'medio-pictum' has the smallest net assimilation and daily net carbon sequestration, which are 33.7 $mmol \cdot m^{-2} \cdot s^{-1}$ and 1.19 $g \cdot m^{-2} \cdot d^{-1}$, respectively.

4.2 Cluster Analysis of Daily Net Carbon Sequestration of Plants

Based on the calculation results of the daily net carbon sequestration of each plant, the Ward's method (also known as the sum of squares method) provided in the system cluster of the SPSS statistical analysis [4]software is used to perform cluster analysis on the daily net carbon sequestration of each plant. The aim of Ward's method is to merge objects (groups) with the smallest growth of deviation (variance) within a group, thereby establishing as homogeneous classes as possible. Each plant is regarded as a class, and the daily net carbon sequestration of each tree species is used as a feature vector to measure the plant's absorption of CO_2. Ward's method is used to cluster the daily net carbon sequestration of tree species. The results are shown in Figure 2.

From Figure 2, it can be seen that Ward's method clusters the daily net carbon sequestration of 25 plants into three categories: The first category includes Ivy, Rubusobcordatus, and Chrysopogon aciculatus. The second category includes Cosmos bipinnatus, Boston ivy, Camphor tree, Osmanthus, Ovatus aureus, Morning glory, Canna, Blackberry lily, Cape jasmine, and Chlorophytum comosum 'medio-pictum'. The third category includes Fatsia japonica, Forsythia, Bougainvillea, Ligustrum quihoui, Camellia, Mirabilis jalapa, Sisal hemp, Loquat, Fragrant eupatorium herb, Honeysuckle, White clover, and Neyraudia reynaudiana. Therefore, in the selection of plants for planting on steep slopes, from the perspective of carbon sequestration and oxygen release, it is recommended to choose more plants from the first and second categories and appropriately match them with plants from the third category.

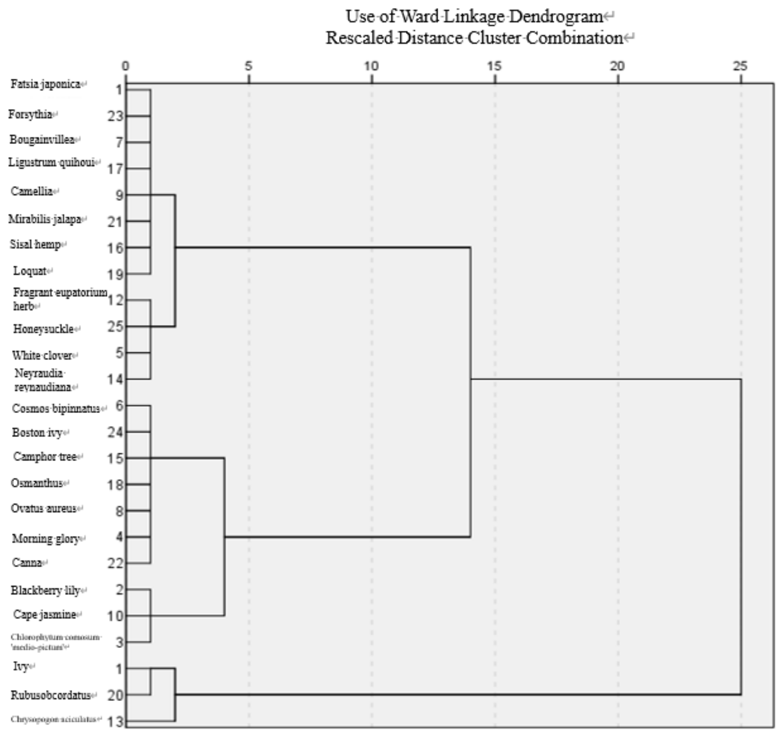

Figure 2 Dendrogram of Cluster Analysis of Daily Net Carbon Sequestration of Plants

4.3 Daily Net Oxygen Release of Tree Species

According to the calculations of formula (1) and (3), the daily net carbon sequestration of 25 kinds of plants was obtained. As can be seen from Table 1, the Chrysopogon aciculatus has the largest daily net oxygen release, which is 13.54 $g \cdot m^{-2} \cdot d^{-1}$, and the Chlorophytum comosum 'medio-pictum' has the smallest daily net oxygen release, which is 0.86 $g \cdot m^{-2} \cdot d^{-1}$.

Table 1 25 Common Slope Greening Plants in the Yunnan Region

Serial No.	Species	Family	Genus	Net Assimilation	Daily Net Carbon Sequestration	Daily Net Oxygen Release
1	Ivy	Araliaceae	Hedera	390.6	13.74	10.00
2	Blackberry lily	Iris family	Belamcanda Adans.	108.8	3.83	2.80
3	Chlorophytum comosum 'medio-pictum'	Lily family	Chlorophytum Ker Gawl.	33.7	1.19	0.86
4	Morning glory	Convolvulaceae	Pharbitis Choisy	168.4	5.93	4.31
5	White clover	Fabaceae	Trifolium L.	295.0	10.38	7.55
6	Cosmos bipinnatus	Asteraceae	Cosmos Cav.	158.7	5.59	4.06
7	Bougainvillea	Nyctaginaceae Juss.	Bougainvillea Comm. ex Juss.	226.9	7.99	5.80
8	Ovatus aureus	Celastraceae R. Br.	Euonymus L.	174.3	6.14	4.46
9	Camellia	Theaceae	Camellia L.	258.7	9.11	6.62
10	Cape jasmine	Rubiaceae	Gardenia J. Ellis	78.3	2.76	2.00
11	Fatsia japonica	Araliaceae	Fatsia Decne. & Planch.	238.9	8.41	6.11
12	Fragrant eupatorium herb	Asteraceae	Eupatorium L.	315.8	11.12	8.08
13	Chrysopogon aciculatus			528.9	18.62	13.54
14	Neyraudia reynaudiana	Poaceae	Neyraudia Hook. f.	287.0	10.10	7.35
15	Camphor tree	Lauraceae Juss.	Camphora Fabr.	176.9	6.23	4.53
16	Sisal hemp	Agavaceae	Agave L.	255.6	9.00	6.54
17	Ligustrum quihoui	Oleaceae	Ligustrum L.	209.2	7.36	6.36
18	Osmanthus	Oleaceae	Oleaceae genus	179.3	6.31	4.59
19	Loquat	Rosaceae	Eriobotrya	250.4	8.81	6.41
20	Rubusobcordatus	Rosaceae	Rubus	429.2	15.11	10.99

21	Mirabilis jalapa	Nyctaginaceae Juss.	Mirabilis	261.1	9.19	6.69
22	Canna	Cannaceae Juss.	Canna L.	186.7	6.57	4.78
23	Forsythia	Oleaceae	Forsythia Vahl	239.9	8.44	6.14
24	Boston ivy	Vitaceae Juss.	Parthenocissus Planch.	149.4	5.26	3.83
25	Honeysuckle	Caprifoliaceae Juss.	Lonicera L.	317.3	11.17	8.12

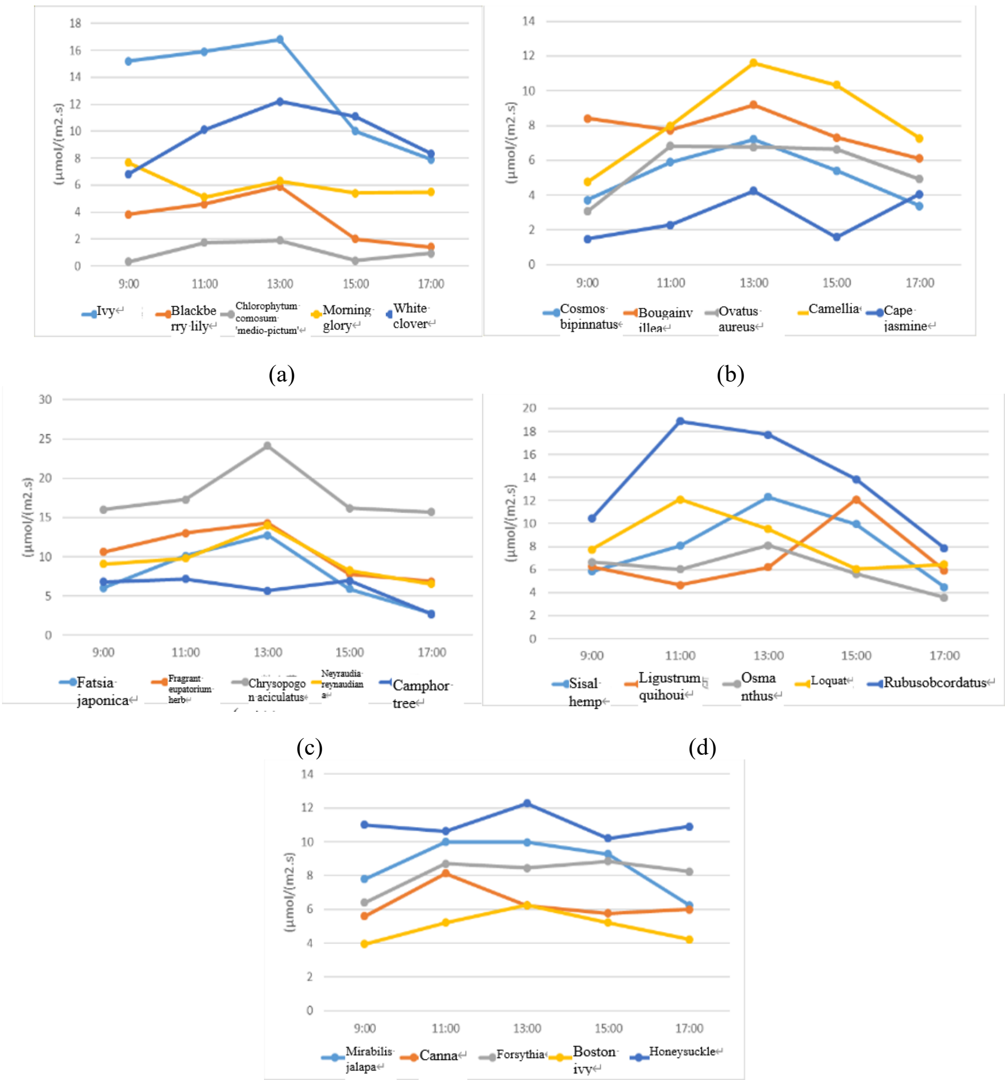

Figure 3 Daily Net Photosynthetic Rate Curves of Each Plant

4.4 Daily Changes in Plant Net Photosynthetic Rate

The daily changes in the net photosynthetic rate of each plant are shown in Figure 3. From Figure 3, it is evident that within 1 day, the daily changes in the net photosynthetic rate of each plant vary. Some exhibit a single-peak curve, where the photosynthetic rate increases with the increase in light intensity and decreases with the decrease in light intensity. Examples include Sisal hemp, White clover, Ivy, Blackberry lily, Camellia, Cosmos bipinnatus, Cape jasmine, Chrysopogon aciculatus, Fragrant eupatorium herb, and Neyraudia reynaudiana. However, the moment the peak value appears differs. The peak value of most tree species appears at 13:00 noon, and a small number of plants reach the highest peak of the day at around 11:00, after which the net photosynthetic rate drops rapidly.

5. Conclusion

The level of plant net photosynthetic rate determines the size of its carbon sequestration and oxygen release ability. However, the changes in the plant's net photosynthetic rate are related not only to the biological characteristics of the tree species but also to many external ecological factors. Photosynthesis in plants is the process of energy transformation with the external environment. In this process, plants fix CO_2 in the atmosphere in their bodies and release O_2. The higher the net carbon sequestration, the more CO_2 and O_2 the plant exchanges with the outside world, and the higher the content of organic matter fixed in the body. Among the tree species selected in this study, Chrysopogon aciculatus has the strongest carbon sequestration and oxygen release ability, and the weakest is the Chlorophytum comosum 'medio-pictum'. The remaining rankings are: Rubusobcordatus > Ivy > Honeysuckle > Fragrant eupatorium herb > White clover > Neyraudia reynaudiana > Mirabilis jalapa > Camellia > Sisal hemp > Loquat > Forsythia > Fatsia japonica > Bougainvillea > Ligustrum quihoui > Canna > Osmanthus > Camphor tree > Ovatus aureus > Morning glory > Cosmos bipinnatus > Boston ivy > Blackberry lily > Cape jasmine. From the perspective of slope carbon sinks, the construction of landscaping tree species can prioritize the selection of plants with large carbon sequestration potential and beautiful vegetation, such as Ivy, Honeysuckle, Bougainvillea, etc.

However, given the constraints of the project's research period and workload, this project only tested a part of the commonly used greening plants, and the test scope did not cover all applicable greening plant species. The follow-up research work will further expand the test range of plant species. Moreover, the performance test of plant carbon sequestration and oxygen release in different seasons needs to be further deepened in future work.

References

[1] Li Junfeng. Doing a good job in carbon peaking and carbon neutralization to welcome the new era of low-emission development [J]. Finance and Economics Think Tank, 2021, 6(04):67-87+142.

[2] LI Bin, XIAO Runmou, YAN Shengyu, et al. Highway Transportation Situation in China[J]. Transportation Journal of Transportation Engineering, 2020, 20(04): 184-193.

[3] LI Sitao, LIU Zhiqiang, LI Peifeng, et al. Low-carbon ecological technology of highway service area discussion on Low-carbon Ecological Technology System for Highway Service Areas [J]. Highway Transportation Science and Technology, 2020, 37(02):56-61.
[4] M. Xu, C. Xue. Research on Technology and Measures to Enhance the Carbon Sink Capacity of Vegetation in Carbon Neutral Service Areas [J].Transportation Energy Conservation and Environmental Protection, 2021, 17(05):10-1.
[5] Han Zizhu. Discussion on greening ecological project of Shaanxi highway toll station [D]. Xi'an: Chang'an University, 2015.
[6] Carbon sink afforestation and carbon sink monitoring technology of highway interchange hubs [J]. Transportation Energy Saving and Environmental Protection, 2014, 10(06):32-38.Zhang Jiao, Li Haiming, Shi Yongjun, et al. Analysis of Photosynthetic Carbon Fixation Characteristics of 30 Plain Afforestation Tree Species [J]. Journal of Southwest Forestry University, 2012, (6). DOI: 10.3969/j.issn.2095-1914.2012.06.002.
[7] Liu Jiajun, Wang Zhigang, Yan Aihua, et al. Photosynthetic Characteristics and Carbon Sequestration and Oxygen Release Functions of 12 Ornamental Tree Species [J]. Journal of Northeast Forestry University, 2011, (9). DOI: 10.3969/j.issn.1000-5382.2011.09.008.
[8] Li Haimei, He Xingyuan, Song Li. Study on Photosynthetic Characteristics and Influencing Factors of 3 Shrub Tree Species [J]. Journal of Shenyang Agricultural University, 2007, (4). DOI: 10.3969/j.issn.1000-1700.2007.04.036.
[9] Han Huanjin. Carbon Sequestration and Oxygen Release Effect of Urban Greening Plants [J]. Journal of Northeast Forestry University, 2005, (5). DOI: 10.3969/j.issn.1000-5382.2005.05.025.
[10] Ehlen J. Fracture characteristics in weathered granites [J]. Geomorphology, 1999, 31(1-4): 29-45. DOI: 10.1016/s0169-555x(99)00071-9.
[11] Dong Yanmei, Zhang Yinke, Guo Chao, et al. Study on Carbon Sequestration and Oxygen Release Benefits of 10 Garden Tree Species in Hangzhou West Lake Scenic Area [J]. Journal of Northwest Forestry University, 2013, (4). DOI: 10.3969/j.issn.1001-7461.2013.04.43
[12] Asmamaw L B, Mohammed A A. Effects of slope gradient and changes in land use/cover on selected soil physico-biochemical properties of the Gerado catchment, north-eastern Ethiopia[J]. International journal of environmental studies, 2013, 70(1): 111-125. DOI: 10.1080/00207233.2012.751167.
[13] Temps R C, Coulson K L. Solar radiation incident upon slopes of different orientations[J]. Solar energy, 1977, 19(2): 179-184. DOI: 10.1016/0038-092x(77)90056-1.
[14] Zhang Xiaoquan. China CDM Afforestation and Reforestation Project Guide [M]. China Forestry Publishing House, 2006.
[15] Xiong Xiangyan, Han Yongwei, Gao Xinting, et al. Study on Carbon Sequestration and Oxygen Release Functions of 17 Common Greening Plants in the Rural-urban Continuum of Beijing [J]. Journal of Environmental Engineering Technology, 2014, (3). DOI: 10.3969/j.issn.1674-991X.2014.03.041.
[16] Chen Yuehua, Liao Jianhua, Qin Shini. Photosynthetic Characteristics and Carbon Sequestration and Oxygen Release Measurement of 19 Garden Plants in Changsha Area [J]. Journal of Central South University of Forestry and Technology, 2012, (10).
[17] Liu Hairong, Song Li, Xian Jingping. Comparative Study on Carbon Sequestration and Oxygen Release Ability of 5 Common Shrubs [J]. Journal of Anhui Agricultural University, 2009, (2).
[18] Li Yongxiu, Wei Yougang, Xu Guobin, et al. Comparison of Different Measurement Methods of Leaf Area Index of Ornamental Pineapple [J]. Jiangsu Agricultural Science, 2008, (4). DOI: 10.3969/j.issn.1002-1302.2008.04.054.

[19] Zhu Yanqing. Study on Carbon Sequestration, Oxygen Release and Cooling and Humidification Effects of Common Shrubs--Taking Changsha City as an Example [J]. Central South University of Forestry and Technology, 2013.