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Seasonal Dynamics of Carbon Dioxide Concentration and its Influencing Factors in Urban Park Green Spaces in Northeast China

Han Gu*(**), Wen Yu Zheng*, Da Wei Xu*†, Ying Huang*, LiYuan Zheng****, and Jian Ma*****

*Postdoctoral Program of Landscape Architecture, Northeast Forestry University, Harbin 150040, China
**College of Architecture and Planning, Chongqing Jiaotong University, Chongqing 400074, China
***College of Art and Design, Nanjing Forestry University, Nanjing 210037, China
****Northeast Forestry University Library, Northeast Forestry University, Harbin 150040, China
*****Department of Mathematics, Ohio State University, Columbus OH 43210, USA
†Corresponding author: Da Wei Xu

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ABSTRACT

Urban green space, as an important component of an urban ecosystem, plays an important role in improving the urban living environment, maintaining ecological balance and reducing carbon dioxide concentration. Few studies are focused on carbon dioxide emissions in urban green spaces of cold regions. To thoroughly understand the temporal and spatial variation laws of carbon dioxide concentration and its influencing factors in urban green spaces in cold regions, a LI-COR LI-840 non-dispersive infrared gas analyser was used to explore the variations in the carbon dioxide concentrations of different plant community green spaces at the syringa Park in Qunli New District of Harbin and their influencing factors. Diurnal variation, seasonal variation, annual dynamics, and temporal and spatial distributions of carbon dioxide concentration in the growing season of four types of park green spaces, namely, larix, birch, syringa, and grassland communities, were observed through experiments. Air temperature, surface temperature, air humidity, and atmospheric pressure in the four types of green spaces were measured to further analyse the correlation among the diurnal variation of carbon dioxide concentration, seasonal variation of carbon dioxide concentration, and the corresponding factors of different vegetation types in parks. Moreover, the annual regression equation of carbon dioxide concentration was established. Results show that the carbon dioxide concentration in different community green spaces exhibits an obvious diurnal variation and a tendency of decreasing first and then increasing over time. The seasonal dynamics of carbon dioxide concentration in different types of park green spaces are different. The carbon dioxide concentration of the larix green space is the lowest (dynamics), whereas that of the grassland space is the highest (357.17±30.18 μmol/mol). The larix seasonal dynamics demonstrates the change with the seasons, from highest to lowest as autumn>spring>summer. Temperature is the main controlling factor that affects the variation in carbon dioxide concentration in the growing season. The carbon dioxide concentrations of larix, birch, syringa and grassland show a highly significant positive correlation with surface and air temperatures. A significantly positive correlation is also observed between atmospheric pressure and variation in carbon dioxide concentration in larix and birch. This study provides data reference and support for spatial ecological planning and layout and the selection of plants in urban park green spaces.

INTRODUCTION

The carbon dioxide concentration in the atmosphere has sharply increased in recent years, thereby causing serious greenhouse effects and posing serious threats to the sustainable development of human economy (Leng et al. 2012). Urban green spaces, such as parks, forests, green roofs, streams, and community gardens, provide critical ecosystem services and promote sports activities for the mental and public health of urban residents (Wolch et al. 2014). These important ecological benefits mainly result from the effect of photosynthesis on reducing the carbon dioxide concentration in environmental spaces and improving other environmental factors. Quantitative studies on the ecological benefits of green spaces, such as carbon dioxide concentration, carbon dioxide flux, carbon sink effect, and health effect (Wu 2014, Chen 2015), have become the focus and trend in the current research field. The increasingly significant effects of urban parks on urban ecosystems have motivated relevant studies on carbon dioxide in urban green spaces (Cameron et al. 2012, Ren et al. 2007, Wu et al. 2010), which are crucial to effectively control greenhouse gas emissions, reducing the negative effects of human activities on global climate change, and improving urban air quality.

The carbon dioxide concentrations of urban green spaces in various environments significantly differ given the regional difference. Studies on winter cities still lag behind. Therefore, the temporal and spatial variations in carbon dioxide concentrations and their influencing factors in different types of green spaces in winter cities should be explored immediately. To determine the spatial and temporal characteristics of carbon dioxide concentration in winter urban green spaces and provide a reference for the subsequent layout and planning of carbon sink green spaces, the diurnal variation, seasonal variation, and environmental influence factor of the carbon dioxide concentration in different types of green spaces were analysed through a non-dispersive infrared gas analyser (LI-COR LI-840) in this study.

STATE OF THE ART

Currently, scholars have investigated the carbon dioxide concentration in urban park green spaces by mainly focusing on carbon sink, reducing carbon dioxide concentration, and carbon flux dynamics in green spaces. Jo et al. (1995) considered that urban green spaces could reduce the carbon dioxide level in the atmosphere and improve the carbon benefit functions of urban green spaces in residential areas; however, sufficient quantitative analyses were lacking. Gratani et al. (2014a) selected sites with different traffic levels and urbanization characteristics in urban centres to compare the changes in carbon dioxide concentration in urban parks with different areas and concluded that the park area was inversely proportional to the carbon dioxide concentration. However, the main influencing factors were not analysed. Gratani et al. (2014b) discussed the effects of different types of vegetation on reducing the carbon dioxide concentration and temperature in cities through the "LAI 2000 plant canopy analyser"; however, quantitative analyses were conducted. Nowak et al. (2002) obtained the vegetation coverage data of urban biomass, growth rate, mortality rate, and litter proportion by a field investigation and analysed the absorption capability of carbon dioxide in vegetation in large cities. However, the research results were only applicable for estimating the carbon sink of urban plants. Cameron et al. (2012) proposed that garden green space was an important part of the urban green infrastructure and confirmed its value to ecosystem service from the perspective of a quantitative study of carbon dioxide. However, the dynamic characteristics of carbon dioxide emission were not considered. Zheng et al. (2015) established the regression equation between the vegetation index of urban green spaces and carbon storage through remote sensing technology and verified the correlation between normalized vegetation index and aboveground carbon pool in urban green spaces. Precipitation is an insignificant factor that influences the change in carbon storage in urban green spaces in Xi'an. Remote sensing technology is unsuitable for studying urban parks. Ueyama et al. (2016) studied the carbon dioxide flux in different urban areas through eddy covariance method. The results showed that the photosynthetic uptake of urban parks was the main control factor for the seasonal variation in carbon dioxide flux. The carbon dioxide emission was the lowest in summer, and the absorption phenomenon even occurred. However, the environmental factors were not considered. Pan et al. (2012) measured the variation in the annual carbon dioxide concentration at the Beijing Olympic Forest Park by using an infrared carbon dioxide analyser and confirmed that the vegetation coverage and level of the park could effectively reduce the carbon dioxide concentration, but relevant model equations weren't established. Zang et al. (2014) analysed the environmental factors of green spaces through a statistical method, and drew the conclusion that the ecological effects of urban green spaces spread to the periphery from the centre of green spaces, and proposed an ecological and efficient pattern of green spaces in high-density central areas, which was based on the physical ecological benefit of green space but was unrelated to carbon dioxide. Bao et al. (2013) observed the diurnal variation in the carbon dioxide concentration of five typical urban green plants in different forest green spaces in the same season. The carbon dioxide concentrations of arbor and shrub structure green spaces were the lowest, whereas that of grassland was the highest; however, the timescale was relatively small. Zhang et al. (2016) used Keeling plot equation and ISO Source software in analysing and confirming the effects of arbor-shrub-grass green spaces on reducing the carbon dioxide emitted by vehicles. But the models required considerable observational support. Xu et al. (2014) analysed the vegetation respiration and negative feedback of carbon dioxide concentration in the atmosphere through Stella software according to system dynamic principle; however, different plant communities weren't discussed. Shi et al. (2015) obtained the spatial distribution pattern of carbon dioxide in a campus through the simulation technology of computational fluid dynamics, coupled greenbelt carbon sequestration function through carbon dioxide space data to reveal the optimal boundary of plant carbon fixation effect, and proposed a spatial layout pattern of green space in the campus; nevertheless, the dynamic structure of green space was not analysed. Deng et al. (2013) surveyed the diurnal variation, seasonal variation, and influencing factors of ecosystem greenhouse gas flux in urban green spaces through a closed dynamic flux tank method and suggested the selection of flowers and plants in urban green spaces from the perspective of reducing the emission of greenhouse gas. However, the greenhouse gas flux of arbor was not analysed. The above studies mainly focused on reducing carbon dioxide concentration by urban green space and the variation of carbon flux of green space. Discussions on the temporal and spatial variations in the carbon dioxide concentrations of different types of green spaces in winter cities were scarce. In this study, the spatial and temporal dynamic images of carbon dioxide are constructed by gas concentration calculation and environmental factor statistical analysis. Moreover, the correlation among surface temperature, air temperature, atmospheric pressure, air humidity, and carbon dioxide in different vegetation green spaces is discussed, thereby providing data support for the selection and layout planning of vegetation types in urban green spaces.

MATERIALS AND METHODS

General situation of the research area and setting of sample plots: The Syringa Park is located at the junction of the Qunli Avenue and Jingjiang West Road, Harbin, in northeastern China and covers an area of 67.4 hectare. This study selected four typical plant communities at the Syringa Park (Table 1): larix forest, birch forest, syringa, and grassland communities. The area of each sample plot was 20 m × 20 m. Three sample points were set in each sample plot, that is, 12 sample plots. In situ determination was conducted in sunny, windless, or breezy weather to reduce the influences and disturbances of weather changes. This study was conducted from May to October 2015.

Sample collection and analysis: A non-dispersive infrared gas analyser LI-840A was used for gas acquisition analysis. The instrument connection, debugging operation, and data reading were in accordance with the requirements of the LI-840 operation manual. The sampling was conducted from 8:00 of May 22, 2015 to 18:00 of October 23, 2015. The sample plots were observed at a distance of 1.5 m from the ground. The data were read every 2 h. All data were read in 3 min after the instrument reading was stable. The data read interval was set to 10s. The sample plots were observed twice continuously or at intervals in the same month under the weather condition similar to that of the first observation. That is, the sample plots were observed for three times every month. All the collected gas concentration and the correlation coefficient of sampling time (R^2>0.95) were considered effective.

Monitoring methods: The data were analysed and processed through SPSS20.0 statistical analysis software package and Microsoft Office Excel 2007. Least-significant difference method was used to compare the differences among different data groups, and the correlation among different factors was evaluated through Pearson correlation coefficient. The significance level was set at α=0.05. All figures were drawn through Sigmaplot10.0.

RESULTS AND ANALYSIS

Diurnal Variation Characteristics of Carbon Dioxide Concentration

Fig. 1 illustrates the diurnal variation trend and characteristics of carbon dioxide concentrations of four types of vegetation green space in the Syringa Park in the growing season. Significant differences were observed in the diurnal variation in the carbon dioxide concentration in various green space environments. The diurnal variations in green spaces with complex vegetation community structure, such as the larix and birch green spaces are as follows: The carbon dioxide concentration in the green space environment is the highest from 8:00 to 18:00 and the lowest from 12:00 to 14:00.

The diurnal variations in shrub and grassland green spaces obviously fluctuated. The average concentrations of four types of green space range from 311.56 μmol/mol to 376.43 μmol/mol. The average concentration of an L-type green space is the lowest, whereas that of a G-type green space is the highest. The average concentration of the C-type green space substantially changes. The carbon dioxide concentration of the L-type green space slightly changes from 8:00 to 14:00. The lowest concentration at 14:00 is 289.67 μmol/mol, and the concentration rapidly increases to 355.57 μmol/mol at 18:00. The concentration of B sample plot reduces the most from 377.09 μmol/mol at 8:00 to 292.89 μmol/mol at 12:00, and the variation amplitude is 84.2 μmol/mol. The concentration changes slowly from 12:00 to 16:00, and the average variation rate is 4.77 μmol/(mol·h). Meanwhile, the concentration variation rate from 16:00 to 18:00 rises rapidly, and the average variation rate is 25.23 μmol/(mol·h). The carbon dioxide concentration

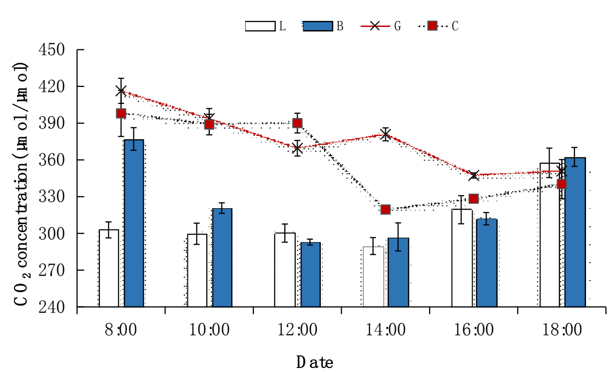

Fig.1: Diurnal variations in the carbon dioxide concentrations of different types of community green spaces in the Syringa Park.

Table 1: Types and basic characteristics of plant communities in sample plots of a forest at the Syringa Park.

Sample plots	Community structure	Vegetation type	Main plants	Canopy density
L	Arbor+grass	Coniferous evergreen and deciduous mixed forest	*Larix gmelinii*, *Pinus sylvestris* var. mongolica litvin, *Poa pratensis*	0.51
B	Arbor+ shrub+grass	Deciduous broad-leaved forest	*Betula platyphyll*, *Amygdalus triloba*, *Hosta plantaginea*, *Poa pratensis*	0.75
D	Shrub+grass	Shrub	*Syringa oblata*, *Poa pratensis*	0.23
Z	Grassland	Grass cluster	*Poa pratensis*	0

Table 2: Correlation of diurnal variation, seasonal variation and environmental factors of carbon dioxide concentration in park green spaces.

Site	Gas	Surface temperature °C	Air temperature	Air humidity	Atmospheric pressure
L	Carbon dioxide (day)(n=18)	-0.593	-0.03	-0.695	0.101
B		-0.649	-0.504*	0.676	0.310
G		-0.891**	-0.873**	0.727	0.528
Z		-0.909*	-0.923*	0.804	0.645
L	Carbon dioxide (seasonal)(n=36)	-0.819**	-0.718**	-0.618	0.597*
B		-0.626**	-0.572**	-0.070	0.513**
G		-0.397**	-0.501**	0.170	0.070
Z		-0.458**	-0.415**	0.113	0.151

reaches the highest value of 377.09 μmol/mol at 8:00. The change range of the carbon dioxide concentration of the C-type sample plot is 319.49-397.95 μmol/mol, and the change value is 78.46 μmol/mol. The trend of diurnal variation is different among various types of community green space. The diurnal variation curves of the carbon dioxide concentration in L and B green space correspond to the changes in solar radiation intensity. The change curves of G and C green space fluctuate significantly when the concentration is relatively low.

Seasonal Variation Characteristics of Carbon Dioxide Concentration

Seasonal variation in the carbon dioxide concentration in the larix community green space: Fig. 2a depicts the dynamic change in the carbon dioxide concentration in the larix green space with the season, which shows the dynamic variation of autumn>spring>summer. The average carbon dioxide concentration in the growing season is 307.49±25.77 - 336.51±21.02 μmol/mol, and the average concentration is 325.19±20.45 μmol/mol. The carbon dioxide concentration gradually decreases in spring, reaches the lowest level in summer (291.69±11.63 μmol/mol), slowly increases in autumn, and reaches the highest level in late autumn (361.02±21.02 μmol/mol), thereby showing the seasonal distribution pattern of carbon dioxide concentration that is decreasing first and then rising with season. The average carbon dioxide concentrations in the larix community green space in spring (May-June), summer (July-August), and autumn (September-October) are 331.59±20.24, 307.19±19.92, and 336.51±21.02 μmol/mol, correspondingly. The average concentration in autumn is 1.09 times of that in summer.

Seasonal variation in the carbon dioxide concentration in the birch community green space: The seasonal variation curve of the carbon dioxide concentration in the birch community green space is irregular (Fig. 2b). The average carbon dioxide concentration in the growing season is 325.20±30.54 μmol/mol. The variation range of the carbon dioxide concentration in spring is less than 5.7%. In summer, the concentration variation shows alternate increasing and decreasing change trends. The concentration drops to the lowest value of 291.19±5.46 μmol/mol at the end of August and then increases. In September, the concentration changes slightly. In October, the concentration increases significantly and reaches the maximum (365.00±10.22 μmol/mol). The average concentrations in spring, summer, and autumn are 353.89±38.17, 302.02±12.77, and 339.39±30.15 μmol/mol. The average carbon dioxide concentration significantly decreases by 10.91%-10.91% ($p<0.05$) in summer compared with those in the two quarters of spring and autumn. The carbon dioxide in birch forest changed with the growing season, from highest to lowest as autumn>spring>summer.

Seasonal variation in the carbon dioxide concentration in the syringa community green space: The carbon dioxide concentration curve of the syringa plant community

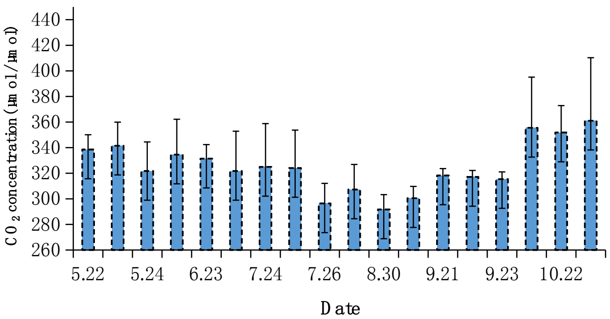

Fig. 2a: Seasonal variation in carbon dioxide concentration in the larix community green space.

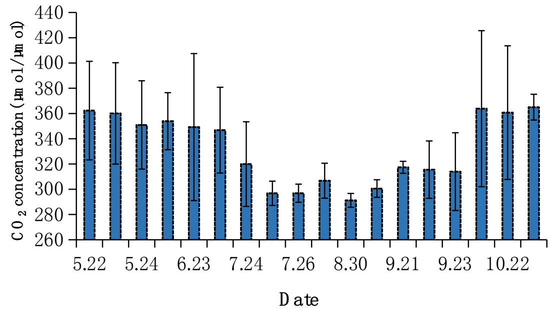

Fig. 2b: Seasonal variation in carbon dioxide concentration in the birch community green space.

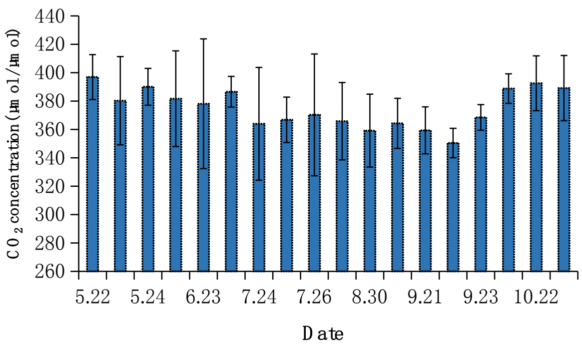

Fig. 2c: Seasonal variation in carbon dioxide concentration in the Syringa community green space.

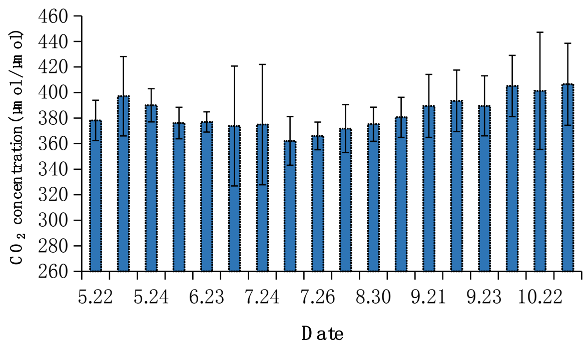

Fig. 2d: Seasonal variation in carbon dioxide concentration in grassland.

Fig.2: Seasonal variation in carbon dioxide concentration in different types of community green spaces in the Syringa Park.

green space in the growing season shows an irregular change (Fig. 2c). The concentration range is 350.42±10.37-396.92±15.82 μmol/mol, and the average carbon dioxide concentration is the highest in spring. The concentrations in spring and autumn are close to a difference of only 2%. The concentration in summer is the lowest (365.06±28.20 μmol/mol), but the lowest concentration occurs in September. The variation curve of carbon dioxide concentration of the syringa community green space in the growing season is different from that of the three other types of green space, thereby showing a seasonal variation pattern of spring> autumn>summer.

Seasonal variation in the carbon dioxide concentration in grassland community green space: In Fig. 2d, the carbon dioxide concentration curve of the grassland green space in the growing season shows a shallow "concave" shape, and the average concentration is 383.81±23.67 μmol/mol. In spring, the concentration decreases and reaches the lowest value (362.13±19.03 μmol/mol) on July 25th. Afterwards, the concentration change shows a linear increase in September and reaches the peak concentration value (406.49±32.10 μmol/mol) in October. The carbon dioxide concentrations in spring, summer, and autumn are 382.04±21.18, 371.80±20.81, and 397.60±29.01 μmol/mol, and the seasonal variation range is minimal. The carbon dioxide concentration of the grassland community green space in the growing season indicates the seasonal variation of autumn>spring>summer.

Interannual Change Characteristics of Carbon Dioxide Concentration in Different Community Green Spaces

In Fig. 3, the annual concentrations of carbon dioxide vary in different types of green spaces. The average carbon dioxide concentration of the park green space was higher in 2014 than in 2015. The concentrations of the larix and grassland community sample plots were 12.17 and 37.953 μmol/mol ($p>0.05$), respectively, which were higher than those in 2015. The concentrations of the birch and shrub community sample plots were 9.66 and 18.10 μmol/mol ($p<0.05$), correspondingly, higher than those in 2015. In the two growing seasons, the carbon dioxide concentration of the larix community is the lowest, whereas the concentration of the grassland community green space is the highest, thereby showing the annual change pattern of L<B<G<C. The interannual variations in the carbon dioxide concentrations of the four types of sample plots present a specific func-

tional relationship (Fig. 4). The carbon dioxide concentration variations of four types of sample plots showed a quadratic function (1) in 2014 and a linear relation (2) in 2015.

$$y_{2014} = 0.5275x^2 - 19.282x + 301.82, R^2 = 0.9039 \quad ...(1)$$

$$y_{2015} = 10.828x^2 + 49.661x + 397.11, R^2 = 0.7873 \quad ...(2)$$

Where, y is the average carbon dioxide concentration of the park green space; x is the average carbon dioxide concentration of the park green space; R^2 is correlation coefficient.

Correlation between Average Carbon Dioxide Concentration and Environmental Factors in the Park During the Growing Season

Table 2 summarizes the correlation between the diurnal and seasonal variations in carbon dioxide concentration and the temperature, humidity, and atmospheric pressure in different types of vegetation community green space in the growing season. Temperature, as the main influencing factor of carbon dioxide in urban park green spaces, significantly influences the seasonal carbon dioxide concentration and its diurnal variation. The influence of temperature on the diurnal variation in carbon dioxide in the larix and birch vegetation green space is relatively low. No significant correlation exists between carbon dioxide concentration and temperature. Surface and air temperatures display a significantly negative correlation with the diurnal variation in carbon dioxide in shrub and grass green space ($p<0.01$). The seasonal variations in carbon dioxide in the four types of green space demonstrate a significantly negative correlation with surface and air temperatures. The seasonal effect of atmospheric pressure on carbon dioxide concentration is significantly higher in the larix and birch green spaces than that in other types of green spaces, thus indicating a significantly or extremely significant positive correlation ($p<0.01$). The correlation with diurnal variation is insignificant. Air humidity in environmental factors is insignificantly related to the diurnal and seasonal variations in carbon dioxide concentration in each vegetation green space. Temperature has a significant effect on the carbon dioxide concentration in green spaces, whereas air wetland has a minimal influence.

Influence of Carbon Dioxide Concentration on the Spatial Distribution Pattern of Different Vegetation Green Spaces in the Growing Season

The characteristics of a diurnal variation curve of carbon dioxide concentration in urban park green spaces show that plants can absorb carbon dioxide in green space environments through photosynthesis and effectively reduce its concentration. This study indicates that an effective photosynthetic radiation determines the intensity and efficiency of photosynthesis. The effective solar radiation increases gradually from 08:00 to 11:00 during sunny days in the growing season, and the intensity efficiency of photosynthesis increases significantly. Therefore, the carbon dioxide concentration in most types of parks is reduced rapidly; this reduction is consistent with the research results of local scholars. The intensity of vegetation photosynthesis in green space reaches the peak after enhancing photosynthetically effective radiation in the afternoon. Therefore, the carbon dioxide concentration in the green environment is the lowest at 14:00 in the afternoon. The total photosynthesis of green space vegetation is inhibited with the decrease and change in solar radiation intensity and solar light quality, and concentration gradually increases from 15:00 to 18:00. Photosynthesis increases the relative humidity of air in the environment with the increase in temperature. The results denote that the increase in air humidity inhibits the photosynthesis of plant community and rapidly increases the carbon dioxide in the green space environment (Yin et al. 2009).

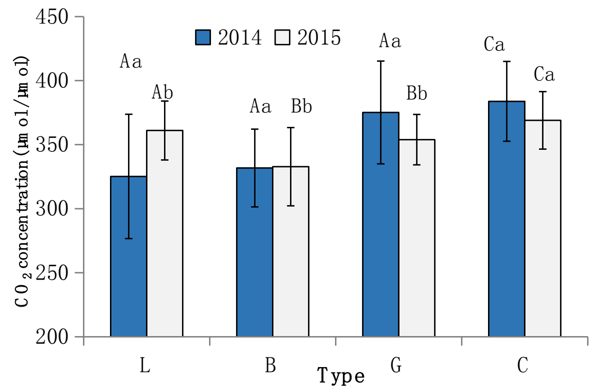

Fig. 3: Interannual variation in carbon dioxide concentration in different types of community green spaces.

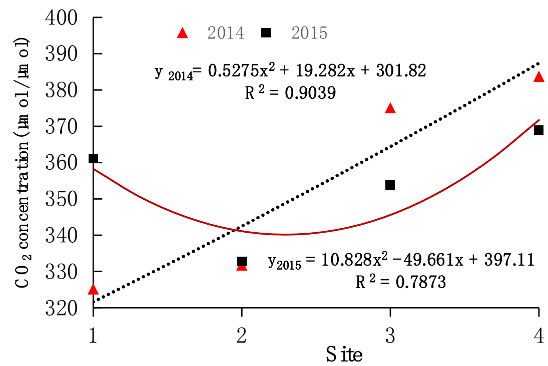

Fig. 4: Interannual variation function characteristics of carbon dioxide concentration.

The differences in green vegetation community and planting mode also influence the spatial and temporal distributions of carbon dioxide concentration in green spaces. The experimental results show that the average carbon dioxide concentration in the larix community green space is the lowest. The concentrations of birch, deciduous broadleaf community, and syringa shrub are high. The concentration of the grass community is the highest, and the average concentration in the growing season is 1.05 times of the larix green space. The concentration is low when the plant community structure is complex (Pan et al. 2011). An increasing quadratic function tendency occurs among different community structures. The role of carbon sink in urban park green spaces has been confirmed in previous studies. A difference is determined in the carbon dioxide concentrations of various types of green spaces in the community park in the growing season, thereby indicating the effects of vegetation type and community planting mode on the carbon dioxide concentration in the environment.

Related studies have shown that vegetation coverage and level richness in green space are inversely proportional to carbon dioxide concentration. The carbon dioxide concentration in space with high vegetation coverage and rich vegetation level is low and vice versa. This phenomenon may result from the different physiological activities of various plants. The results show that the physiological structure and metabolism of plants are the primary factors that affect the function and efficiency of carbon dioxide absorption in plants. The plant community formed by different plant types (species and tree age) also directly affects the absorption of carbon dioxide and the efficiency of oxygen emission. The multilevel plant community structure composed of trees, shrubs, and grasses has higher green quantity than the single plant community structure. The comprehensive utilization efficiency of light is also high, thereby showing excellent carbon dioxide absorption capacity. The multilevel plant community structure has different distribution ratios to water, light, and other substances that affect plant photosynthesis, thus also affecting the overall carbon sequestration efficiency of the multilevel plant community. The density and coverage of plants in different spatial levels are designed reasonably through experimental study and summary to ensure that light, moisture, and other elements can meet the requirements of different levels of community plants and further strengthen their carbon fixation efficiency.

The seasonal dynamic analysis of carbon dioxide in the park indicates that the average carbon dioxide concentration in summer is the lowest at 336.59 μmol/mol; the values in spring and autumn are 363.28 and 362.07 μmol/mol, respectively. Therefore, summer>spring>autumn. The emission intensity varies obviously with seasonal change, hence showing an obvious positive correlation. This result is due to the difference in plant growth status, photosynthesis, and green vegetation coverage in spring, summer, and autumn. In spring, plant growth is gradually restored, the total green amount of green space is less, and the photosynthesis efficiency of the plant community is low (Li et al. 2010). Consequently, the carbon dioxide concentration is relatively high. The rainy season in Harbin is mainly in summer (July and August), and the suitable water and heat conditions promote the growth of plants. Plants consume carbon dioxide in the environment through photosynthesis; thus, the absolute value of carbon dioxide concentration is lower in summer than in spring. The plants gradually stop growing because of the large temperature difference in autumn (September and October) in Harbin. The ecological function of plants is low, and their photosynthetic efficiency is significantly reduced. Therefore, the carbon dioxide concentration is slightly lower in summer than in spring.

Relationship Between Carbon Dioxide Concentration and Environmental Factors in Different Community Green Spaces

Environmental factors, such as temperature, wind speed, solar radiation intensity, and underlying surface type, exhibit a significant or an extremely significant correlation with carbon dioxide concentration in different community green space. The absorption of carbon dioxide in park green space is positively related to temperature and solar radiation. Solar radiation is enhanced, the speed and efficiency of photosynthesis in green plants increase, and the carbon fixation and oxygen release capacity of green plants are improved while temperature rises. The temperature is high in summer and autumn, and the effect of accumulated temperature is obvious. The growth of plants is vigorous, the total green quantity of green space is high, and photosynthesis is stronger than respiration. Considerable carbon dioxide is absorbed, and the carbon sequestration effect is obvious. By contrast, respiration is stronger than photosynthesis, and carbon sequestration efficiency is low (Sun et al. 2012). The carbon dioxide concentrations in larix and birch community sites are highly correlated with atmospheric pressure, which typically varies with latitude, altitude, and temperature. Therefore, the changes in carbon dioxide concentration in different environments are measured. The change in atmospheric pressure leads to the change in gas density, thus affecting the observed results.

CONCLUSION

This study was aimed at comprehensively understanding the temporal and spatial dynamic laws of carbon dioxide concentration in different plant community environments in urban parks and the effects of environmental factors on carbon dioxide concentration. Therefore, the diurnal variation, season, annual dynamics, surface temperature, air temperature, atmospheric pressure, and air humidity factors were analysed through an in situ test observation method. The following conclusions could be drawn:

1. The diurnal variation, seasonal variation, and annual dynamics of carbon dioxide concentration in different vegetation community green spaces in an urban park during the growing season exhibit spatial and temporal differences. The carbon dioxide concentration in the green spaces in the park is significantly higher at 8:00 than at 18:00, and the concentration from 12:00 to 14:00 is the lowest. Seasonal dynamics show the lowest concentration in summer, followed by spring, and the highest in autumn. The annual average carbon dioxide concentration is similar.
2. Vegetation type and planting form exert significant influences on the carbon dioxide concentration. The carbon dioxide concentration is significantly lower in coniferous tree compound structure than that in simple shrub and ground cover structure green space.
3. Temperature is a main influencing factor of carbon dioxide concentration in green spaces. The seasonal effect of temperature is higher on carbon dioxide concentration than on diurnal variation, and a significantly negative correlation is determined between temperature and diurnal carbon dioxide concentration. Air relative humidity insignificantly influences carbon dioxide concentration.

This study shows the variation characteristics and influencing factors of carbon dioxide concentration in different time and space on the basis of experimental observation of carbon dioxide concentration in different green spaces in an urban park. Experimental data support is provided for ecological planning and construction of urban green spaces. Urban park green space is affected by urban environment, and significant differences exist in soil, plant community, and tree age structure. Therefore, the variation in carbon dioxide concentration in park green spaces should be monitored extensively to provide accurate and scientific guidance to the spatial layout of urban green spaces.

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