Seasonal Variation of Air Oxygen Content Inside and Outside *Phyllostachys edulis* Forests

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Abstract This study was conducted to investigate the air oxygen content inside and outside a *Phyllostachys edulis* forest in Qishan Forest Park throughout all four seasons. (1) Regarding the overall annual variation in oxygen content in both environments, comparative analysis of the annual average oxygen concentration showed that the average inside the forest was 22.13%, while the value outside it was 21.39%. The annual average oxygen concentration inside the forest was 3.34% higher than that outside the forest. (2) Regarding the seasonal variation in oxygen content at both sites, the oxygen concentration inside the forest was consistently higher than that outside the forest in all four seasons. The oxygen concentrations inside the forest were 22.1%, 21.9%, 21.8%, and 21.5% in spring, summer, autumn, and winter, respectively, while outside the forest, they were 22.0%, 21.8%, 21.7%, and 21.4% for the same seasons, respectively. (3) The diurnal variation trends of oxygen concentration at both sites were similar throughout all four seasons, exhibiting a single-peak and double-trough curve pattern. The peak period occurred at 13:00 in spring, summer, and winter, and at 9:00 in autumn. The trough periods were observed at 7:00 and between 21:00 and 23:00 or at 5:00.

Key words *Phyllostachys edulis* forest; Air oxygen content; Seasonal variation
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Oxygen is a primary product of animal metabolism and the "source of power" for human survival. Daily, large amounts of oxygen must be inhaled to sustain life. Studies have shown that forest plants can effectively fix carbon, release oxygen, and maintain the balance between carbon and oxygen. The main reason is that plants absorb carbon dioxide and release oxygen through photosynthesis, alleviating hypoxia in local areas and thereby improving air quality[1]. The carbon sequestration and oxygen release benefits of forests consist of two components: the oxygen release benefit and the carbon dioxide absorption benefit. Currently, analyzing the carbon sequestration and oxygen release benefits of forest plants is an indispensable part of studying the role of urban forests in improving the ecological environment[1-2]. While scholars have extensively researched the "quantity" of carbon sequestration and oxygen release by forest vegetation, studies specifically focusing on the contribution of *Phyllostachys edulis*, a common plant species in southern China, to air oxygen content remain scarce[3]. In this study, the seasonal variation in air oxygen content indise and outside a *P. edulis* forest in an urban forest park was continuously monitored, aiming to provide a theoretical reference for forest resource management and the development of recreational forests.

Materials and Methods

General situation of the study area and site selection

Fuzhou Qishan Forest Park covers an area of 2 804 hm^2. It is adjacent to the urban area and a national highway, offering convenient transportation. It serves as one of the main venues for nearby residents to exercise, rest, and recreate. The bamboo forest within the park is located in the southwest direction, with bamboo ages ranging from 2 to 5 years, an average height of 16 m, an average diameter at breast height (DBH) of 23 cm, and a canopy density of 0.73. Eight replicates were established inside the forest, spaced 10 m apart. Open areas located 10, 15, and 20 m away from the *P. edulis* forest were selected as external control points[1].

Indicator measurement and analysis methods

A domestically produced portable oxygen sampler was used to measure air oxygen content, with a fixed sampling time of 2 min. During measurement, a tripod was used to secure a flat platform, and the instrument was placed horizontally on it at a height of approximately 1.6 m to minimize experimental error[1].

Data processing, analysis and chart drawing were performed using Microsoft Excel 2007 software.

Results and Analysis

Overall annual variation of oxygen content in both environments

Comparative analysis of the annual average oxygen concentration inside and outside the forest shows that the average inside the forest was 22.13%, while the value outside it was 21.39%. The annual average oxygen concentration inside the forest was 3.34% higher than that outside the forest. One-way ANOVA revealed a significant difference between the two. The relatively higher annual average oxygen content inside the forest may be attributed to the presence of various plant species in addition to bamboo,

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particularly during spring and summer when physiological activity is heightened. During the day, photosynthesis releases substantial amounts of oxygen into the forest environment[1,4].

Seasonal variation of oxygen content in both environments

Regarding the seasonal variation in oxygen content at both sites, the oxygen concentration inside the forest was consistently higher than that outside the forest in all four seasons. The oxygen concentrations inside the forest were 22.1%, 21.9%, 21.8%, and 21.5% in spring, summer, autumn, and winter, respectively, while outside the forest, they were 22.0%, 21.8%, 21.7%, and 21.4% for the same seasons, respectively. The oxygen concentration inside the forest was higher than that outside the forest by 0.45%, 0.45%, 0.46%, and 0.46% in spring, summer, autumn, and winter, respectively. The oxygen content inside the forest in winter showed significant differences compared with spring and summer, while no significant differences were observed among spring, summer, and autumn. Similarly, outside the forest, winter exhibited significant differences compared with spring and summer, while no significant differences were observed among the first three seasons. Additionally, the figure indicates that the oxygen content inside the forest during the growing season was consistently higher than during the non-growing season. The ranking of oxygen concentration in the four seasons, both inside and outside the forest, was as follows: highest in spring, followed by summer and autumn, and lowest in winter. This seasonal pattern further demonstrates that during the peak growing season, plants exhibit stronger physiological activity. Particularly around midday when sunlight is most intense, photosynthesis exceeds respiration, leading to the highest oxygen release, especially in spring and summer. During this period, the forest canopy density is high, and the dense branches and leaves, along with thriving understory shrubs and herbaceous plants, collectively contribute to photosynthesis and oxygen release, significantly increasing the oxygen content inside the forest. Conversely, in autumn and winter, plant physiological activity gradually declines as they enter dormancy. With leaves fallen, photosynthesis nearly ceases, resulting in a significant reduction in oxygen release[1,5].

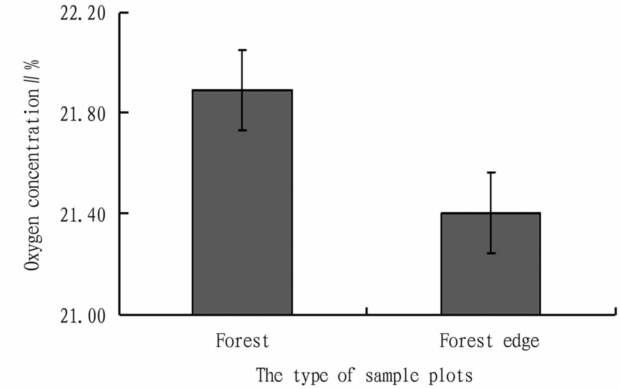


Fig. 1 Annual average value of oxygen content in two types of sample plots

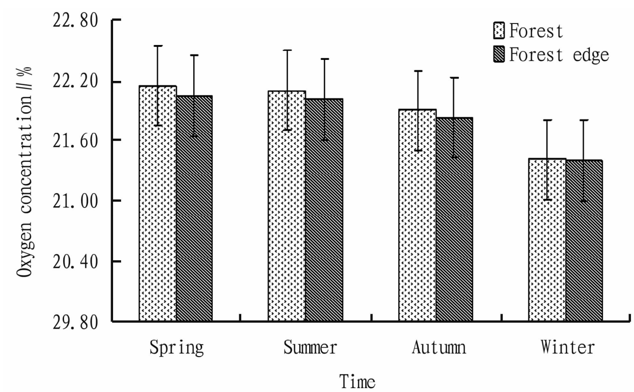
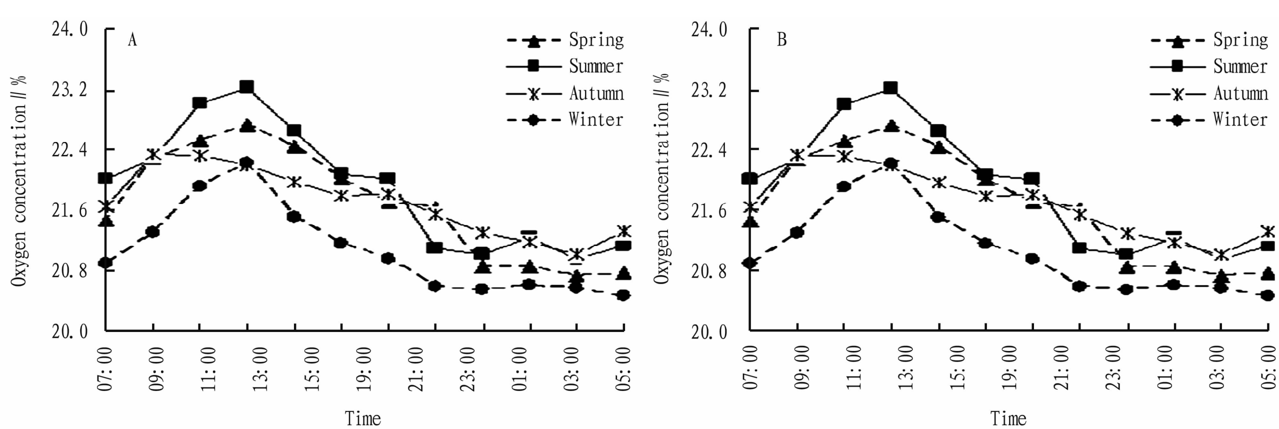


Fig. 2 Seasonal variation of air oxygen content in two types of sample plots



A. Forest; B. Forest edge.

Fig. 3 Diurnal variation of air oxygen content in two types of sample plots

Diurnal variation of oxygen content in both environments

The diurnal variation trends of oxygen concentration at both sites were similar in all four seasons, exhibiting a single-peak and double-trough curve pattern. The peak period occurred at 13:00 in spring, summer, and winter, and at 9:00 in autumn. The trough periods were observed at 7:00 and between 21:00 and 23:00 or at 5:00. The differences in oxygen content between the peak and trough periods inside the forest were extremely significant. This pattern was largely consistent with the diurnal variation of light intensity for plants, further demonstrating that the intensity of photosynthesis determines the level of oxygen content in the forest. During early morning and evening, plants exhibit poor carbon sequestration and oxygen release capacity, resulting in the lowest oxygen content of the day. As the solar elevation angle gradually increases and light intensity strengthens, plants begin photosynthesis and release oxygen. Around midday, when light intensity peaks, oxygen release reaches its maximum. Subsequently, as the solar elevation angle decreases, the capacity for oxygen release gradually declines, dropping to its lowest level again by evening[1].

Conclusions and Discussion

(1) Regarding the overall annual variation in oxygen content in both environments, comparative analysis of the annual average oxygen concentration showed that the average inside the forest was 22.13%, while the value outside it was 21.39%. The annual average oxygen concentration inside the forest was 3.34% higher than that outside the forest. One-way ANOVA revealed a significant difference between the two.

(2) Regarding the seasonal variation in oxygen content at both sites, the oxygen concentration inside the forest was consistently higher than that outside the forest in all four seasons. The oxygen concentrations inside the forest were 22.1%, 21.9%, 21.8%, and 21.5% in spring, summer, autumn, and winter, respectively, while outside the forest, they were 22.0%, 21.8%, 21.7%, and 21.4% for the same seasons, respectively. The oxygen concentration inside the forest was higher than that outside the forest by 0.45%, 0.45%, 0.46%, and 0.46% in spring, summer, autumn, and winter, respectively.

(3) The diurnal variation trends of oxygen concentration at both sites were similar throughout all four seasons, exhibiting a single-peak and double-trough curve pattern. The peak period occurred at 13:00 in spring, summer, and winter, and at 9:00 in autumn. The trough periods were observed at 7:00 and between 21:00 and 23:00 or at 5:00. The differences in oxygen content between the peak and trough periods inside the forest was extremely significant.

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