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ASSESSING GROWTH AND DEVELOPMENT OF DENDROCALAMUS ASPER IN AN URBAN AND INDUSTRIAL PARK REPLANTATION: IMPLICATIONS FOR SUSTAINABLE PARK MANAGEMENT

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ABSTRACT

The issue of maintaining ecological balance in urban and industrial park settings necessitates innovative approaches to sustainable replantation. This study addresses this challenge by exploring the viability of Dendrocalamus asper, a fast-growing and widely distributed bamboo species in Peninsular Malaysia, for such replantation projects. Recognized for its economic value in bamboo shoot production and ecological benefits, D. asper has the potential to enhance sustainable park management by promoting ecological preservation and safeguarding cultural landscapes from overdevelopment. An experimental study was conducted to monitor the growth of D. asper in two contrasting environments, focusing on the relationship between air quality and bamboo growth rates. The study, carried out in collaboration with Majlis Bandaraya Ipoh (MBI), evaluated D. asper alongside other species planted simultaneously, emphasizing its adaptability and performance under varying environmental constraints. This research aims to support the integration of D. asper into urban and industrial park replantation strategic planting to ecological restoration and sustainable green infrastructure development.

Keywords: *Dendrocalamus asper, Sustainable Park Management, Ecological Restoration, Bamboo Replantation, Urban and Industrial Park*

INTRDODUCTION

Park management, as categorized by Aly and Dimitrijevic (2022), involves three critical elements: human resources, financial resources, and material resources. In many countries, public park managers face challenges such as reduced budgets, diminished financial support, and a loss of skilled personnel. To address these issues, modifications to traditional approaches or the introduction of new strategies, such as planting native species, can significantly improve outcomes. Native plants, by their adaptive and responsive nature, offer enhanced resistance to local environmental stressors, contribute to the stabilization of native ecological systems, and require less maintenance due to their natural compatibility with the environment.

Bamboo species, particularly Dendrocalamus asper (D. asper), exemplify such strategic planting solutions. This species plays vital socio-economic, ecological, and cultural roles within communities. It is an essential resource for agricultural practices, providing materials for construction, furniture, wood fuel, and musical instruments. Additionally, it serves as a source of food, medicine, and fodder, while contributing to soil and water conservation, biodiversity support, and climate change mitigation (Alemayehu & Hido, 2023).

With its hard trunk, D. asper is highly valued for its structural qualities, making it suitable for construction purposes. Its ease of propagation, rapid growth rate, and adaptability to cultivation further position it as a lucrative resource for generating supplementary income. According to Razak et al. (2014a), the species has also gained significant commercial demand locally and internationally, with exports to markets such as Singapore from Kulai, Johor. These attributes underscore the potential of D. asper as a sustainable, multifunctional species for park management and ecological restoration.

As urbanization accelerates and green spaces dwindle, the need for innovative and sustainable park management strategies has become increasingly urgent (Nath et al., 2015). Traditional landscaping approaches often overlook the ecological and economic potential of non-woody plants, such as bamboo. Among these, Dendrocalamus asper stands out due to its exceptional attributes, including rapid growth, high biomass production, and its ability to enhance soil quality and atmospheric conditions (Liese

& Weiner, 1996; Scurlock et al., 2000). This resilient species adapts well to diverse environments, making it an ideal candidate for replantation in urban and industrial park settings (Embaye et al., 2005). Integrating bamboo into park management strategies offers multifaceted benefits, including enhanced biodiversity, urban heat mitigation, and overall ecological health improvements (Peng et al., 2020). D. asper is particularly advantageous due to its low maintenance requirements and resilience to anthropogenic stressors, aligning seamlessly with the goals of sustainable urban development and landscape design (Nugroho & Ando, 2001). Additionally, D. asper plays an essential role in local economies, providing materials for construction, furniture, food, and even energy, making it a valuable resource for urban and industrial applications.

In the urban context of Ipoh, Majlis Bandaraya Ipoh, as an authoritative government body, has a pivotal role in championing bamboo, particularly D. asper, as an alternative material for sustainable construction. Promoting local cultivation and utilization of bamboo could reduce dependency on imports while fostering economic growth and ecological benefits within the region. Such initiatives highlight the untapped potential of bamboo as a key element in advancing sustainable urban ecosystems.

Thus, this study seeks to explore the integration of D. asper in urban and industrial park replantation projects, with a focus on its growth dynamics, ecological benefits, and potential for improving urban resilience.

This study aims to evaluate the growth dynamics of D. asper within urban and industrial park contexts. It also seeks to assess the species' environmental benefits, including its role in supporting biodiversity through peak-hour surveys of associated flora and fauna. Ultimately, this research establishes D. asper as a viable planting strategy for sustainable park management, contributing positively to urban ecosystems, enhancing ecological integrity, and fostering urban resilience. The findings aim to position bamboo as a transformative element in urban landscaping and park management.

Thus, the objective of this research as below to evaluate the growth performance of Dendrocalamus asper in urban and industrial park settings through pictorial studies. To assess the impact of D. asper replantation on

air quality, focusing on carbon level reduction. To explore the implications of D. asper growth for sustainable park management in urban and industrial contexts.

LITERITURE RIVIEW

Bamboo, particularly *Dendrocalamus asper*, has attracted significant attention for its ecological, socioeconomic, and cultural contributions. As a fast-growing and easily propagated species, it is increasingly employed in sustainable landscaping and urban park management. Despite its widespread adoption, gaps remain in understanding the influence of environmental factors on its growth and adaptability, particularly in urban and industrial settings.

This review synthesizes previous research on D. asper, focusing on its growth and propagation, economic potential in landscape projects, and its cultural significance in Malaysia. By identifying existing knowledge gaps, this review provides a foundation for exploring D. asper's potential to enhance urban green spaces while reducing maintenance costs and fostering ecological and social resilience.

Socioeconomic Contributions

D. asper plays a pivotal role in socioeconomic development. Bamboo plantations contribute to community resilience by diversifying income sources and reducing reliance on traditional timber resources. The species rapid growth ensures a consistent supply of raw materials, supporting small-scale enterprises involved in harvesting, processing, and manufacturing bamboo-based products. This creates job opportunities and stimulates rural economies. Additionally, bamboo contributes to affordable and sustainable construction, especially in rural areas. Its use in housing, furniture, and energy production provides communities with cost-effective solutions while addressing environmental concerns. Bamboo-based initiatives, such as training programs and cooperative ventures, empower communities to manage resources sustainably, ensuring long-term socioeconomic benefits. Bamboo-related economic activities are estimated to provide livelihoods for approximately 750,000 Ethiopians, illustrating its potential to alleviate

poverty and enhance rural development (Alemayehu & Hido, 2023).

Growth Characteristics and Applications

Dendrocalamus asper, or buluh betung, is a towering species reaching heights of 20–30 meters with culm diameters ranging from 8–20 cm. Its prominent nodes, thick-walled culms, and leathery sheaths make it ideal for construction and ecological landscaping (Liese & Kohl, 2015; Virtucio & Roxas, 2003). Its adaptability to diverse environmental conditions and resistance to fractures make it a valuable material for engineered wood products, offering a sustainable alternative to traditional timber (Wang et al., 2024). Culturally, bamboo is deeply embedded in traditional practices and crafts. It serves as a material for household items, musical instruments, food production, medicinal applications, and more. Its lightweight and earthquake-resistant properties make bamboo houses a sustainable and affordable construction option, particularly in seismic regions (Alemayehu & Hido, 2023).

Environmental Benefits

Bamboo plantations provide significant environmental benefits, including land restoration and erosion control. Studies in Ethiopia (e.g., Desalegn & Tadesse, 2014) highlight bamboo's role in agroforestry systems, where it serves as windbreaks, shelterbelts, and protective barriers along riverbanks. Bamboo's ability to sequester carbon dioxide, produce oxygen, and support biodiversity makes it an effective tool for improving environmental health and aesthetics in both rural and urban landscapes. In addition, bamboo's contribution to carbon sequestration aligns with global sustainability goals. By capturing atmospheric carbon, bamboo mitigates climate change while offering practical environmental services such as improving air quality and providing habitats for various species. In conclusion, the versatility of D. asper in addressing ecological, economic, and cultural needs underscores its value in sustainable development. However, further research is required to fully understand its adaptability to varied environmental conditions and its long-term benefits in urban and industrial contexts. By integrating D. asper into park management strategies, there is potential to create resilient urban ecosystems while fostering socioeconomic and environmental sustainability.

Air Quality Index and Bamboo: A Sustainable Connection

Carbon farming involves practices that enhance the removal of CO2 from the atmosphere, converting it into plant material or soil organic matter. For carbon farming to be effective, carbon gains from improved land management must exceed carbon losses. Bamboo, known for its rapid growth and high biomass accumulation, has significant potential for carbon storage. This makes bamboo an ideal candidate for carbon farming and trading, as it can capture and store carbon efficiently, reducing atmospheric CO2 levels and positively enhancing air quality. In addition to carbon storage, bamboo helps improve air quality by absorbing particulate matter and harmful particle like nitrogen dioxide and sulfur dioxide, which influence to better Air Quality Index (AQI) scores. Bamboo's role in carbon farming and trading, more research is conducted, bamboo is likely to play an increasingly important role in improving air quality and reducing carbon emissions. (Nath et al., 2015)

MATERIAL AND METHODOLOGY

Study Sites and Experimental Design

This study focuses on two distinct sites to evaluate the growth and ecological contributions of *Dendrocalamus asper* in different environments: UAC Berhad and Taman Rekreasi DR Seenivasagam, representing industrial and urban park settings, respectively. Both sites have been part of bamboo replantation initiatives since 2017, offering valuable insights into the adaptability and performance of D. asper across contrasting landscapes.

The UAC Berhad Industrial Park (Figure 1) serves as a representative industrial site, characterized by a highly altered environment with limited vegetation and higher exposure to anthropogenic activities. Bamboo replantation in such areas aims to explore its potential for mitigating industrial pollution, enhancing soil stabilization, and contributing to green infrastructure. Conversely, Taman Rekreasi DR Seenivasagam (Figure 2), a well-known urban park in Ipoh, represents a more naturalized setting. This site provides a platform to study how

D. asper integrates into existing green spaces, supporting biodiversity, improving air quality, and offering recreational and aesthetic value to the community.

The selection of these sites highlights the versatility of D. asper as a species capable of thriving in heterogeneous conditions, making it a valuable candidate for sustainable urban and industrial park management. This comparative study of bamboo growth in the two environments aims to provide actionable data for optimizing replantation strategies and maximizing ecological benefits.

Figure 1. Open space at UAC Berhad as an Industrial Park

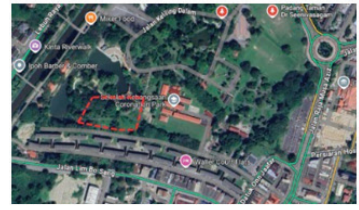

Figure 2. Taman Rekreasi DR Seenivasagam as an Urban Park

Environmental Monitoring

Environmental parameters were monitored with Delta Ohm instruments to assess the impact of *D. asper* replantation on air quality, focusing on carbon level reduction around the bamboo. Delta Ohm sensors were selected for their accuracy in field conditions and their suitability for long-term ecological monitoring (Delta Ohm, 2021). Temperature and Humidity: Delta Ohm temperature and humidity sensors were positioned at both canopy and ground levels in each plot to capture microclimate variation. Hourly data collection allowed for the identification of diurnal and seasonal temperature trends, assessing D. asper's role in mitigating urban heat effects (Peng et al., 2020).

Carbon Dioxide level: Portable air quality monitors from Delta Ohm were deployed to measure CO_2 levels, tracking D. asper's impact on local air quality. These readings were averaged by three points (Point 1 = 0.5meter away from the leaves), Point 2 = 1.5 meter away from the leaves, and Point 3 = 2.5 meter away from the leaves) (Figure 3) under the bamboo canopy for more accurate data, allowing fluctuations due to urban activity (Nath

et al., 2015; Delta Ohm, 2021)

RESULTS AND DISCUSSION

Physical Growth Observation

The bamboo conditions at Taman Rekreasi DR Seenivasagam reveal several challenges that impact growth and harvesting practices. Observations indicate a 10 nos number of bamboo clumps on-site. The bamboo is propagated on site through culm and cult cutting propagation The site is ideal to grow with bamboo as it is located nearby the lake. The bamboos reach an average height of o.5 meters (Figure 4) only and the average bamboo culm diameter at the site is recorded at just 7mm (Figure 5), which is significantly smaller than what is typically expected for healthy bamboo growth. This condition suggests that the bamboo is either stunted or underdeveloped. Such a small diameter could also result from overcrowding of bamboo clumps, which restricts the space and resources each culm can access. Furthermore, the harvesting conditions are suboptimal, with the bamboo deemed "unready for harvesting," possibly due to immature growth or inadequate cultivation techniques. The harvesting methods are also categorized as poor, which may hinder sustainable bamboo management and regeneration. These findings highlight the need for improved cultivation practices, including the adoption ofsustainable harvesting techniques, to maximize the potential for bamboo growth at this site. An additional factor contributing to poor harvesting methods is the uncontrolled harvesting by nearby residential community.

The bamboo conditions at open space nearby UAC Berhad demonstrate well- maintained growth and harvesting practices compared to other sites. Observations indicate a total of 20 bamboo clumps on-site, suggesting a well-managed plantation with adequate spacing and resources to support healthy bamboo development. The culm growth is notable, with an average diameter of 30mm (Figure 6), which aligns with expectations for mature bamboo. This robust growth indicates favorable environmental conditions, proper soil management, and sufficient nutrient availability. The bamboos at this site reach an impressive height of 1.5 meters (Figure 7), showcasing optimal growth potential. This height reflects effective

cultivation techniques. Furthermore, the bamboo is categorized as "ready for harvesting," signifying that the plantation is mature and meets the criteria for sustainable harvest (Figure 8). The harvesting method employed is described as "good," implying that careful and sustainable techniques are used to ensure minimal damage to the clumps and encourage regeneration for future cycles. The combination of healthy growth parameters and good harvesting practices at UAC Berhad highlights it as a benchmark for bamboo cultivation and management. Such practices can serve as a model for other sites seeking to improve their bamboo growth and harvesting outcomes.

Figure 4: Bamboo height approximately at 0.5m at Taman Rekreasi DR Seenivasagam

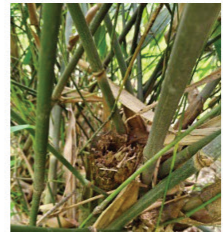

Figure 5: Culm growth of 7mm diameter at Taman Rekreasi DR Seenivasagam

Figure 6: Average culm diameter of 30mm at UAC Berhad.

Figure 7: Bamboo height of approximately at 1.5m at UAC Berhad.

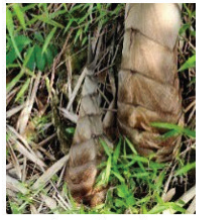

Figure 8: Bamboo shoot is not aggresively harvested, allowing to regenerate into mature stem for sustainable harvest at UAC Berhad.

Figure 9: Water availability at bamboo plantation at UAC Berhad

Table 1. Physical Growth Observation after 7 years (2017-2024) of Bamboo Planting

Site Location	Number of bamboos clump	Culm growth in diameter	Bamboo Height	Harvesting duration	Harvesting method	Clumps observations on site
Taman Rekreasi DR Seenivasagam	10 nos	7mm	0.5m	Unready culm	Poor method	Poor
UAC Berhad	20 nos	30mm	1.5m	Ready culm	Good method	Good

The UAC Berhad site benefits from a well-maintained drainage system (Figure 9), featuring a drainage channel central that efficiently channels excess water away. This setup ensures that the soil remains well-drained, preventing waterlogging while maintaining consistent moisture levels essential for bamboo growth. As a result, bamboo at this site thrives with uniform growth, robust culms, and minimal risk of root rot or fungal infections. The stable drainage also contributes to a balanced microclimate, allowing the bamboo to flourish even during heavy rainfallTaman Rekreasi DR Seenivasagam also Using a lake as the drainage system for bamboo planting, particularly when the lake is only 2 meters away, offers risks of over-saturation and waterlogging, which could hinder bamboo growth if drainage is not well-managed The lake-based approach supports biodiversity and ecological sustainability by creating a symbiotic relationship between bamboo and aquatic systems. However, it requires careful planning, such as incorporating buffer vegetation to filter runoff and prevent soil erosion. Comparing the two systems, lake-based strategies align more closely with sustainable practices, while UAC methods emphasize urban productivity and efficiency.

This observation compares bamboo growth and management in two parks, Taman Rekreasi DR Seenivasagam and the open spaces at UAC Berhad, to evaluate growth performance and the impact of sustainable harvesting. At Taman Rekreasi DR Seenivasagam, bamboo has a smaller diameter of 7mm and reaches only 5m in height. It remains unready for harvesting and suffers from poor harvesting practices. In contrast, bamboo at UAC Berhad, with a larger diameter of 30mm and a height of 15m, demonstrates successful sustainable harvesting due to effective methods. These differences suggest that bamboo at UAC Berhad benefits from better health and usability. It is recommended that bamboo grow at a larger radius from the community to prevent aggressive harvesting. This likely involves

selective cutting to promote regrowth and long-term productivity.

Environmental Monitoring

The Table 2 shows the analysis compares carbon dioxide (CO_2) levels between the area of UAC Berhad and Taman Rekreasi DR Seenivasagam throughout the day at 24 November 2024 and 25 November 2024, respectively. The data indicates that CO_2 levels are consistently higher at the area of UAC Berhad, with an average of 391 ppm compared to 163 ppm at Taman Rekreasi DR Seenivasagam. The area of UAC Industrial Park shows a peak in CO_2 levels during the morning hours, followed by a gradual decline throughout the day, although data for 4:00 PM and 5:00 PM is unavailable due to heavy rain. In contrast, Taman Rekreasi DR Seenivasagam maintains significantly lower CO_2 levels, with a relatively steady pattern of decline as the day progresses. The graph illustrates (Figure 10) this disparity clearly, emphasizing that Taman DR Seenivasagam provides a cleaner air environment compared to the industrialsetting of UAC Berhad. This difference can likely be attributed to factors such as vegetation density, park design, or proximity to industrial activities.

The data comparing conditions at UAC Berhad and Taman Rekreasi DR Seenivasagam at Table 3 reveals some notable differences in relative humidity, wind velocity, and temperature. At UAC Berhad, the average relative humidity (RH) is 56.12%, with values ranging from 46% in the morning to 75% at 7:00 AM. In contrast, Taman Rekreasi DR Seenivasagam shows a higher average RH of 60.13%, with a range between 49.7% and 69%. UAC Berhad generally has lower humidity, particularly in the morning hours. Regarding wind velocity, UAC Berhad experiences an average of 0.3 m/s, with values ranging from 0.1 m/s to 0.6 m/s throughout the day. Meanwhile, Taman Rekreasi DR Seenivasagam has a slightly higher average wind velocity of 0.4 m/s, with observed peaks, particularly at 3:00 PM (1.3 m/s) and 4:00 PM (0.5 m/s). In terms of temperature, UAC Berhad has an average of 34.6°C, ranging from a cooler 29.8°C in the early morning to a hotter 37.6°C at 3:00 PM. On the other hand, Taman Rekreasi DR Seenivasagam shows a slightly lower average temperature of 33.8°C, with temperatures fluctuating between 32.8°C at 3:00 PM and 36.4°C at 11:00 AM. Overall Taman Rekreasi DR Seenivasagam experiences slightly higher RH, wind velocity, and more consistent temperatures compared to UAC

Berhad, where conditions show more fluctuation, particularly in RH and temperature.

Table 2. Air Quality Monitoring in PPM

Time	UAC Berhad			Average	Taman Rekreasi DR Seenivasagam			Average
	Point 1	Point 2	Point 3		Point 1	Point 2	Point 3	
7:00	499	489	476	488	*N/A	*N/A	*N/A	*N/A
8:00	475	472	481	476	*N/A	*N/A	*N/A	*N/A
9:00	451	286	319	352	*N/A	*N/A	*N/A	*N/A
10:00	431	459	448	446	86	73	54	71
11:00	429	443	442	438	214	225	298	245
12:00	421	384	397	400	225	218	211	218
1:00	421	384	397	400	56	93	198	115
2:00	364	310	356	343	169	173	207	183
3:00	178	179	160	172	173	163	167	167
4:00	**N/A	**N/A	**N/A	**N/A	146	160	160	155
5:00	**N/A	**N/A	**N/A	**N/A	161	148	126	145
Average:	408ppm	378ppm	386 ppm	391 ppm	154 ppm	157 ppm	177 ppm	163 ppm

*N/A: Data unable to be obtained due to technical difficulties
**N/A: Data unable to be obtained due to heavy rain

Due to the technical difficulties while conducting the data collection for solar radiation, the researcher use website (https://gml.noaa.gov/grad/solcalc/azel.html) to obtain solar elevation for both sites. The solar patterns for Taman Rekreasi DR Seenivasagam Park and the area of UAC Berhad are nearly identical due to their likely proximity in latitude and shared environmental conditions, which result in comparable solar angles and sunlight distribution throughout the day. However, UAC Park shows slightly higher solar elevation values, suggesting that it receives slightly more direct sunlight. This makes UAC Berhad marginally more favourable for solar-dependent activities such as energy generation, plant growth, or similar applications that benefit from higher solar intensity and optimal light angles (Table 3).

Figure 10. CO2 Levels in Taman Rekreasi DR Seenivasagam and UAC Berhad Nearby

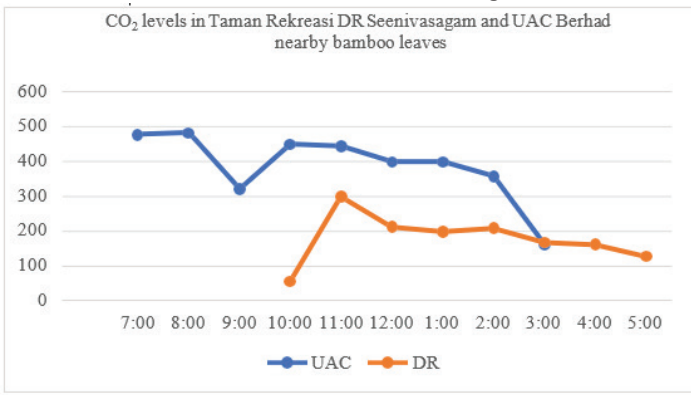

Table 3. The Average of Relative Humidity, Wind Velocity, and Temperature Summarizes at UAC Berhad and Taman Rekreasi DR Seenivasagam

Time Period	RH at UAC Berhad (%)	RH at Taman DR (%)	Wind Velocity at UAC (m/s)	Wind Velocity at Taman DR	Temperature at UAC Berhad (0C)	Temperature at Taman DR (0C)	Solar Elevation at UAC	Solar Elevation at Taman DR
7:00	75.0	*N/A	0.2	*N/A	29.8	*N/A	3.34	3.2
8:00	64.1	*N/A	0.1	*N/A	31.6	*N/A	15.53	15.36
9:00	51.6	*N/A	0.4	*N/A	36.6	*N/A	26.9	26.72
10:00	51.2	61.1	0.4	0.02	36.0	32.9	36.69	36.49
11:00	46.0	49.7	0.2	0.4	37.2	36.4	43.86	43.65
12:00	57.1	58.9	0.1	0.4	33.9	34.0	47.06	46.86
1:00	57.1	58.5	0.4	0.1	33.9	33.5	45.42	45.25
2:00	53.3	69.0	0.6	0.3	34.9	34.9	39.42	39.3
3:00	49.5	63.0	0.2	1.3	37.6	32.8	30.36	30.28
4:00	**N/A	61.7	**N/A	0.5	**N/A	32.9	19.43	19.38
5:00	**N/A	59.1	**N/A	0.6	**N/A	33.2	7.41	7.39
Average	56.1	60.1	0.3	0.4	34.6	33.8	28.7	28.5

*N/A: Data unable to be obtained due to technical difficulties
**N/A: Data unable to be obtained due to heavy rain

CONCLUSION AND FUTURE WORK

This study highlight to evaluate the growth performance of Dendrocalamus asper in urban and industrial park settings through pictorial studies. The comparative analysis shows that environmental factors such as CO_2 levels, sunlight duration, and vegetation density significantly influence bamboo

growth. UAC Industrial Park, characterized by higher CO_2 levels (average 390.78 ppm) and an open environment, demonstrated uniform bamboo growth due to prolonged sunlight exposure. However, environmental stressors like pollutants impacted overall growth robustness In contrast, Taman Rekreasi DR Seenivasagam, as an urban park, with lower CO_2 levels (162.67 ppm), supported healthier bamboo growth. However, bamboo shoots being cut by the surrounding community led to thinner culms and slower growth

This study conclude in assess the impact of D. asper replantation on air quality, focusing on carbon level reduction to enhance bamboo growth and environmental benefits, tailored strategies should be implemented for each site UAC Industrial Park to Introduce more vegetation to reduce pollutants, create abetter microclimate, and enhance carbon sequestration. Strategies to buffer industrial emissions can further support bamboo development. Urban Park to Optimize sunlight distribution by managing competing vegetation to ensure consistent light access for all bamboo clumps. This study examines the growth of Dendrocalamus asper (Betong bamboo) for sustainable park management in urban and industrial contexts. The bamboo offers benefits such as carbon sequestration, improved air quality, and aesthetic value. In urban areas like Taman DR Seenivasagam, Betong bamboo thrives, highlighting its suitability for parks. However, challenges at UAC Industrial Park emphasize the need for site-specific strategies, considering factors like environmental conditions, soil quality, and drainage. The findings stress the importance of tailored management practices to fully utilize Betong bamboo’s ecological and aesthetic benefits in diverse environments.

This study explores the implications of Dendrocalamus asper (Betong bamboo) growth for sustainable park management in urban and industrial contexts. The findings highlight the bamboo's potential as a sustainable planting strategy, offering significant benefits such as carbon sequestration, improved air quality, and aesthetic enhancements. In urban settings like Taman DR Seenivasagam, where Betong bamboo demonstrates healthier growth, its suitability for parks is evident, aligning well with urban greening initiatives.

However, Factors such as environmental conditions, soil quality, and drainage management play critical roles in influencing growth outcomes.

Addressing these variables through tailored management practices is essential to fully realize the benefits of Betong bamboo in diverse settings.

In conclusion, the comparative study of Betong bamboo growth and CO_2 levels between Urban Park and UAC Industrial Park underscores the potential of bamboo as a sustainable planting strategy for park management. The findings reveal that Urban Park 's healthier bamboo growth and lower CO_2 levels were facilitated by supportive environmental conditions such as enriched soil, dense vegetation, and optimized park design. Conversely, UAC Industrial Park's higher CO_2 levels and slower bamboo growth highlight the challenges posed by industrial proximity, compacted soil, and limited greenery.

These outcomes emphasize the need for tailored strategies in different settings to maximize the ecological and aesthetic benefits of bamboo. While urban parks demonstrate bamboo's capability for enhancing air quality and promoting sustainability, industrial parks may require interventions such as soil improvement and increased green coverage to replicate these benefits. This research advocates for incorporating bamboo planting as a versatile and eco- friendly approach to urban and industrial park management, offering valuable insights for creating greener, more sustainable environments.

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