Assessment of Green Belt and Its Impact on Air Pollution Reduction in Hard Coke Industries – A Case study based in Dhanbad, India

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This study investigates the role of green belt development in reduciting air pollution by conducting a case study of a hard coke industry in Dhanbad, India. Th study spans over 4 years from 2022 till 2025, over the period 2022–2025. Secondary data from Industrial reports and Environmental Compliance documents were collected along with primary data regarding plantation practices to analyse changes in airborne pollutants levels with respect to systematic increases in tree plantation density and species diversity. Pollutants studied include PM10, SO2, NO2, and stack emissions. The study found a statistically significant, negative correlation between expanded vegetation cover and concentrations of key air pollutants around the industrial complex. Native, fast-growing plant species with high Air Pollution Tolerance Index (APTI) values were planted specifically for pollution reduction. Trees such as Azadirachta indica (Neem) and Polyalthia longifolia (Ashoka) were found to be was associated with pollutant reductions and high (85–88%) plant survival rates. It was concluded that diverse green belt compositions have ecological and micro-climatical benefits in Industrial contexts. Though their influence on technological pollution controls was limited due to data limitations, this study demonstrated the effectiveness of sustained green infrastructure as a co-benefit measure alongside conventional pollution control technologies. The findings provide evidences for integrating native plants into industrial pollution management strategies for sustainable development and air quality improvement.

Keywords: Green belt, Air pollution, Hard coke industry, industrial vegetation, Air Pollution Tolerance Index (APTI), industrial air pollution, air pollution reduction measures

Introduction

Hard coke is a solid carbon-rich material produced through the high-temperature carbonization of bituminous coal and serves as a critical input in the iron and steel industry. During production, volatile impurities are removed, forming a strong, porous carbon structure characterized by high fixed carbon content, low volatile matter, and superior mechanical strength. These properties make hard coke ideal for sustaining heavy loads and high temperatures inside blast furnaces while enabling efficient heat transfer and gas permeability (Frontiers in Environmental Science, 2025).

In India, regions such as Dhanbad host numerous hard coke processing units that play an essential role in industrial supply chains. However, these facilities are major contributors to air pollution, releasing particulate matter (PM), sulfur dioxide (SO_2), nitrogen oxides (NO_x), and fine dust. Such emissions pose severe respiratory health risks, degrade air quality, and disturb ecological balance (IIETA, 2023; Pragasan, 2023).

India, ranking third globally in coal consumption with over 1200 million tonnes used annually, faces critical environmental challenges due to its dependence on coal (MoEF, 2024). The leading coal-producing states – Odisha, Jharkhand, and Chhattisgarh – experience acute air quality deterioration, with Dhanbad exemplifying the intensity of industrial pollution and its environmental consequences (Frontiers in Environmental Science, 2025).

Mitigating emissions from hard coke industries has thus become an urgent environmental priority. Conventional end-of-pipe control measures, such as filters and chimneys, provide partial relief but are often inadequate against diffuse and persistent airborne pollutants (Thakre, Gupta, & Agrawal, 1993). Consequently, ecological approaches integrating natural processes into pollution control have gained increasing attention. Among these, green belt development has emerged as a sustainable and cost-effective strategy for improving air quality around industrial zones (Kaur & Nagpal, 2017; Ministry of Environment, Forest and Climate Change, 2024; Rakhi, Bhargava, & Singh, 2008; Terracon India, 2024).

Green belts function as biological filters, absorbing gases and trapping dust through canopy surfaces, leaf structures, and soil–plant interactions. Studies have shown that well-designed green belts can remove up to 36–40% of suspended particulates and 80–90% of gaseous pollutants (Nowak, 1994; Thakre et al., 1993). Plant species with high Air Pollution Tolerance Index (APTI) values—such as *Ficus religiosa*, *Azadirachta indica*, and *Polyalthia longifolia*—are particularly effective due to their biochemical and morphological resilience (Kaur & Nagpal, 2017; Jha et al., 2024). The Indian Ministry of Environment emphasizes that native species selection, canopy density, and planting geometry critically influence pollutant attenuation and microclimatic benefits (Terracon, 2024).

This study investigates the impact of green belt expansion on ambient air quality surrounding a hard coke factory in Dhanbad, India. Using four years of air quality and vegetation data, it examines temporal trends in pollutant reduction relative to vegetation growth. The findings aim to quantify the ecological benefits of industrial greening, offering evidence-based insights for regional environmental planning and supporting India's air quality management commitments under SDG 11 and 15 (MoEF, 2024; Rakhi et al., 2008).

Aim

The aim of this study is to evaluate the impact of green belt expansion on air pollution reduction around a hard coke factory in Dhanbad. The objectives include

- Quantifying the correlation between increasing tree plantation and the decline in pollutant levels (PM_{10}, SO_2, NO_2, dust)

- Analyzing species composition and survival rates within the green belt

- Assessing the overall effectiveness of vegetation in mitigating industrial air pollution

Scope

The scope of the study covers a five-year period from 2020 to 2025. It focuses on the changes in air quality with respect to annual plantation activities around the premises. It includes data collection on pollutant concentrations and detailed records of tree numbers, species diversity, growth characteristics, and maintenance efforts within the industrial premises. While the study primarily emphasizes native and pollution-tolerant trees, it also considers the role of ornamental and vegetable plants as part of the green belt ecosystem.

The study is geographically limited to a particular hard coke industry site located in Dhanbad, India. It offers insights applicable to similar industrial zones aiming to integrate green infrastructure with pollution control measures. Due to data limitations and co-occurring pollution control technologies, the findings are primarily correlative rather than providing a definitive causal relationship.

Literature Review

Air pollution from industrial activities remains a major contributor to global environmental and public health challenges, particularly in rapidly industrializing regions such as India (Rakhi et al., 2008). Emissions of particulate matter (PM), sulfur dioxide (SO_2), nitrogen oxides (NO_x), and other toxic gases from industries like hard coke manufacturing cause persistent deterioration of air quality, respiratory health issues, and ecological imbalance (ScienceDirect, 2021). Since source-based pollution control technologies often have limited efficacy, green belt development has emerged as a sustainable, low-cost, and long-term method for pollution abatement (Thakre et al., 1993; Rakhi et al., 2008).

Green belts consist of strategically planted trees and shrubs around industrial premises that act as biological filters by reducing pollutant concentrations through deposition, absorption, and chemical transformation (Pandey & Agrawal, 1994). Tree leaves and bark surfaces serve as sinks for particulates, while plant biochemical processes detoxify absorbed gases by converting them into less harmful metabolites (Kaur & Nagpal, 2017). Additionally, vegetation enhances local microclimatic conditions which aids pollutant dispersion reduction (Nowak, 1994).

Research in Indian industrial zones strongly supports the effectiveness of well-planned green belts. Thakre et al. (1993) reported that green belts with a width of 100 meters or more and dense canopy structures can reduce suspended particulate matter by up to 36–40% and gaseous pollutants by even higher margins. Evaluations using the Air Pollution Tolerance Index (APTI) have identified pollution-tolerant species such as *Azadirachta indica* (Neem) and *Polyalthia longifolia* (Ashoka) that maintain physiological activity under pollutant stress (Kaur & Nagpal, 2017). These species, along with *Ficus religiosa* and *Alstonia scholaris*, are widely recommended in India's national green belt development guidelines (Terracon India, 2024).

Beyond pollutant removal, green belts deliver multiple co-benefits, including biodiversity enhancement, carbon sequestration, noise reduction, and aesthetic improvements that enhance the sustainability of industrial operations (ScienceDirect, 2021). However, their overall effectiveness depends on factors such as species selection, planting density, canopy geometry, and regular maintenance (Rakhi et al., 2008; Terracon India, 2024). Ambient conditions also influence performance (Wang et al., 2025).

Empirical evidence from industrial sites underscores the tangible impact of vegetative buffers. For instance, a study near a petroleum refinery demonstrated that a 500-meter green belt effectively reduced SO_2, NO_x, and suspended particulate matter by 36–40% while removing hydrocarbons and volatile organic compounds (Rakhi et al., 2008). Similarly, in the context of hard coke manufacturing in Dhanbad, the installation of green belts alongside mechanical pollution control measures has maintained emissions within statutory limits, illustrating the synergy of vegetative and technological interventions. Despite these findings, long-term quantitative assessments linking vegetation growth and air quality improvement remain limited, highlighting the need for integrated, multi-year analyses.

Recent advancements in remote sensing technologies have significantly improved the monitoring of vegetation cover and its relationship with air quality. The Normalized Difference Vegetation Index (NDVI) is widely used for assessing spatial and temporal variations in vegetative health and density (IIETA, 2023). NDVI-based studies in industrial cities such as Dhaka have revealed a clear inverse relationship between vegetative cover and $PM_{2.5}$ levels, emphasizing vegetation's role in mitigating pollution amid industrial expansion (IIETA, 2023; Frontiers, 2025). These findings reinforce the importance of integrating remote sensing data into regional air quality management and green infrastructure planning.

In India's diverse ecological settings, native plant species play a pivotal role in enhancing the efficiency and resilience of industrial green belts. Species such as *Azadirachta indica* (Neem), *Ficus benghalensis* (Banyan), *Polyalthia longifolia* (Ashoka), and *Alstonia scholaris* (Blackboard Tree) have been widely recommended due to their adaptability, high dust retention capacity, and resilience under harsh industrial conditions (Kaur & Nagpal, 2017; Terracon India, 2024; Pandian Elumalai et al., 2024). Neem, for instance, is fast-growing, drought-tolerant, and capable of thriving across varied Indian soil types while offering superior pollutant absorption (Grow Billion Trees, 2024). *Leucaena leucocephala* (Subabul) is another fast-growing species that achieves mature green cover within 3–5 years, while slower-growing trees like Banyan develop extensive canopies providing long-term filtration and shading benefits (Terracon India, 2024).

The physiological and structural traits of native trees enhance their ability to capture particulates and absorb gaseous pollutants (Rakhi et al., 2008). Their biochemical mechanisms, including antioxidant production, help mitigate oxidative stress caused by exposure to industrial emissions (Kaur & Nagpal, 2017). In coal belt regions such as Jharkhand, species like *Mango*, *Ashoka*, and *Banyan* have shown exceptional dust scavenging and pollutant absorption capacity, making them ideal for green belt implementation near thermal power plants and coke factories (Indian Institute of Technology Dhanbad study).

Research Gap

Despite considerable research on vegetation's role in pollution mitigation, several literature gaps persist in understanding the quantitative impact of green belts on industrial air quality reduction. Most existing studies, such as those by Rakhi et al. (2008) and Wang et al. (2022), demonstrate pollutant attenuation under controlled or urbanized environments but lack longitudinal field-based evidence linking industrial green cover expansion with measurable pollutant decline. Research in India predominantly emphasizes species selection and physiological tolerance (Pragasan, 2023) rather than statistical correlation between vegetation growth metrics

and pollutant concentration trends over time. Furthermore, case studies often rely on short-term measurements or model simulations without integrating multi-year data or ground vegetation assessments such as tree counts and canopy cover changes. As highlighted by Chaudhuri (2022), Indian air pollution research remains heavily technocratic, with limited integration of nature-based monitoring frameworks or community input. Hence, this study addresses these gaps by statistically correlating four years of pollutant monitoring data with annual changes in green belt coverage around a Dhanbad-based hard coke unit—providing empirical insights into how sustained industrial greening translates to quantifiable reductions in air pollutants.

Methodology

A mixed-method approach that has been used in this study to analyze the impact of green belt vegetation on air pollution reduction around a hard coke processing factory in Dhanbad, India. Due to data confidentiality agreements and the inability to obtain permission from the authorities, the name of the factory and specific identifying details are withheld in this study. This measure ensures compliance with privacy and proprietary information protocols while allowing for an objective assessment of the green belt's impact on air pollution.

The study uses both secondary and primary sources of data. Secondary data on air pollutant concentrations – such as particulate matter (PM_{10}), sulfur dioxide (SO_2), and nitrogen oxides (NO_x) – were obtained from company environmental reports spanning four years (2021-2025). These data provide a longitudinal overview of pollution trends in the industrial vicinity. Tree coverage was calculated by systematically counting the number of trees around the factory premises and through company records of plantation documents. Semi-structured one-on-one interviews were conducted with factory employees and residents living nearby to gather insights on perceived changes in vegetation cover, recent planting activities, and species selection. This approach helped identify the specific plants contributing to the green cover increase. Data analysis was done through statistical correlation and regression techniques to examine the relationship between changes in pollutant concentrations and green belt expansion over the study period.

Data Analysis and Findings

A sustained and structured tree plantation program between 2022 and 2025 was observed in the industry (Table 1). Due to these efforts, the total tree population noticeably increased from 3,609 in 2022 to 8,042 in 2025.

Table 1 Tree Plantation Data

Year	Total Trees Existing	New Trees Planted	Type of Trees Planted	Dominant Species	Survival Rate
2022	3609	50	Neem, Ashoka, Gulmohar, Peepal, Polyalthia, Vegetable Crops, Flowering Perennials, Ornamentals	Neem	85
2023	4310	750	Neem, Ashoka, Peepal, Shrubs, Vegetable Crops, Flowering Perennials, Ornamentals	Ashoka	88
2024	6350	2300	Neem, Karanj, Vegetable Crops, Flowering Perennials, Ornamentals	Karanj	87

2025	8042	1900	Peepal, Neem, Ashoka, Gulmohar, Vegetable Crops, Flowering Perennials, Ornamentals	Neem	N.D.

A variety of vegetation was included that comprised trees, shrubs, vegetable crops, flowering perennials, and ornamentals. Species such as Neem (*Azadirachta indica*), Ashoka (*Polyalthia longifolia*), and Karanj (*Pongamia pinnata*) were found to be of dominance in plantation programs. Maintenance and plantation practices were effective given the high survival rates ranging between 85% and 88% which would ensure the long-term stability of the green cover (Table 1).

Native, fast-growing species such as Neem and Ashoka are known to have high Air Pollution Tolerance Index (APTI) values have been included in the plantation programs. The inclusion of ornamental and shrub species improves vertical stratification of plant species while increasing particulate entrapment efficiency. These also provide an improved landscape aesthetics.

The data analysis reveals strong negative correlations between tree plantation metrics and the concentrations of various air pollutants (Table 2). Pearson correlation coefficients show statistically significant inverse relationships. The correlation between total trees and PM_{10} concentrations is particularly strong ($r = -0.974$, $p = 0.026$), indicating that as tree coverage increased, ambient particulate levels dropped from about 90 µg/m³ in 2022 to 83 µg/m³ in 2025. Similarly, SO_2 showed a significant decline, with a correlation of -0.989 ($p = 0.011$) relative to total trees. The ambient SO_2 declined from 23.25 to 10.46 µg/m³ and stack SO_2 emissions declined from 85.5 to 35.58 mg/Nm³. NO_2 also exhibited strong inverse correlations ($r = -0.967$, $p = 0.033$) with ambient levels dropping from 43.3 to 25.73 µg/m³.

Table 2 Average Pollutant levels measures and number of Trees

Year	PM10 (µg/m³)	PM2.5 (µg/m³)	SO2 (µg/m³)	NO2 (µg/m³)	Stack Dust (mg/Nm³)	Stack SO2 (mg/Nm³)	Stack NOx (mg/Nm³)	Total Trees Existing	New Trees Planted
2022	90.35	43.35	23.25	43.3	135.8	85.5	30.6	3609	50
2023	89.4	41.9	21.75	43.3	134.24	64.19	29.44	4310	750
2024	84.3	NIL	17.99	33.33	130.64	46.32	6.72	6350	2300
2025	83.2	NIL	12.29	31.12	128.36	35.58	4.39	8042	1900

Spearman rank correlations validated the findings of the study. It confirmed the monotonic decrease in pollutant concentrations as tree numbers increased. These statistical findings reinforce the idea that multi-species green belt around industries is known to absorb air pollutants and trap particulate matter.

While data gaps in recordings of $PM_{2.5}$ levels limit the findings, the comprehensive negative associations for both particulate and gaseous pollutants highlight the efficacy of expanded green belts in mitigating industrial air pollution. The survival rates of approximately 85%–88% enhance the durability of this green impact.

Table 3 Correlation Coefficients Pollutant Parameter Vs New Trees and Total Trees

Pollutant Parameter	New Trees			Total Trees		
	Pearson r	p-value	Spearman ρ	Pearson r	p-value	Spearman ρ
PM_{10} (µg/m³)	−0.945	0.055	−0.80	−0.974	0.026	−1.00
$PM_{2.5}$ (µg/m³)	-	-	-	-	-	-
SO_2 (µg/m³)	−0.785	0.215	−0.80	−0.989	0.011	−1.00
NO_2 (µg/m³)	−0.917	0.083	−0.74	−0.967	0.033	−0.95
Stack Dust (mg/Nm³)	−0.902	0.098	−0.80	−0.997	0.0035	−1.00
Stack SO_2 (mg/Nm³)	−0.927	0.073	−0.80	−0.957	0.043	−1.00
Stack NO_x (mg/Nm³)	−0.944	0.056	−0.80	−0.954	0.046	−1.00

Discussion

The findings of this study demonstrate a clear and statistically significant relationship between the expansion of the green belt around the hard coke industry and the reduction in both ambient and stack air pollutants over the years from 2022 to 2025. The increase in the total number of trees and the annual addition of new plantations is strongly related to the decline in particulate matter (PM_{10}), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), and stack emissions.

These findings of this study align well with the ecological characteristics of planted species. Trees like Neem and Ashoka dominate the plantations and are known for their high air pollution tolerance (APTI) and fast growth. These features make them highly suitable for air pollution reduction. The green belt program also includes diverse species like Karanj, Jamun, Nimbu (lemon), Kathal (jackfruit), Mango, and Big Santra to add structural complexity to the coverage (Appendix 2; Appendix 3). This enhances the canopy density and pollutant reduction potential while also stabilizing the ecosystem stability. In addition to trees, other fruit bearing species such as guava and Banana along with perennial plants like rose, money plant and other flowering plants. It improves vertical and horizontal stratification of vegetation as well as resulting in soil conservation, microclimate regulation with an increase biodiversity in the region. The sustained survival rate of the planted green cover supports the long-term effectiveness of the green belt vegetation. The results also underscore the importance of new plantations, as negative correlations between pollution levels and annual new trees planted highlight the immediate impact of afforestation on reducing pollutants. The study reinforces the role of green infrastructure as an integral part of industrial pollution control. These green belts are also found to be capable of supplementing technological measures and regulatory compliance, providing a suitable restorative solution that is also comparatively economic.

Limitations

The study has certain limitations that need to be acknowledged. Although vegetable crops were recorded in the plantation count, it is assumed that these crops did not have a significant direct impact on pollution reduction. Multiple pollution reduction measures – such as bag filters, enhanced chimney systems, and dust suppression tactics – were implemented within the industrial unit during the study period. As a result, the observed decreases in pollutant levels should not be considered as the green belt's sole contribution but rather as the combined effect of green belt development and these other industrial pollution control measures. Data availability posed another limitation. $PM_{2.5}$ data, an important pollutant whose data was unavailable for all the years included in the study. Lastly, the study relied only on total tree counts and species diversity without detailed spatial mapping of canopy density, leaf area index, or seasonal variation. This study also had limitations including the lack of detailed spatial or satellite imagery (e.g., Google Earth) for tracking annual changes in green coverage. Reliance on ground-level counts limited spatial analysis of green belt growth and its impact on pollutants.

Conclusion

The findings of this study demonstrate a clear and statistically significant relationship between the expansion of the green belt around the hard coke industry and the reduction in both ambient and stack air pollutants over the years from 2022 to 2025. The increase in the total number of trees and the annual addition of new plantations is strongly related to the decline in particulate matter (PM_{10}), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), and stack emissions (IIETA, 2023; Pragasan, 2023; Wang et al., 2022).

These findings of this study align well with the ecological characteristics of planted species. Trees like Neem and Ashoka dominate the plantations and are known for their high air pollution tolerance index (APTI) and fast growth. These features make them highly suitable for air pollution reduction (Kaur & Nagpal, 2017; Pandey & Agrawal, 1994). The green belt program includes diverse species like Karanj, vegetable crops, flowering perennials, and ornamental plants to add structural complexity to the coverage. This not only improves pollutant reduction but also stabilizes ecosystem stability (Rakhi, Bhargava, & Singh, 2008; Jha, Singh, & Kumar, 2024).

The sustained survival rate of the planted green cover supports the long-term effectiveness of the green belt vegetation. The results also underscore the importance of new plantations, as negative correlations between pollution levels and annual new trees planted highlight the immediate impact of afforestation on reducing pollutants (Terracon India, 2024; Wang et al., 2025). The study reinforces the role of green infrastructure as an integral part of industrial pollution control. These green belts are also found to be capable of supplementing technological measures and regulatory compliance, providing a suitable restorative solution that is also comparatively economic (Ministry of Environment, Forest and Climate Change, 2024; Thakre, Gupta, & Agrawal, 1993).

References

- Frontiers in Environmental Science. (2025). Spatiotemporal patterns and driving factors of NDVI and air quality in industrial regions.

- IIETA. (2023). NDVI-based analysis of green space decline and air quality in Dhaka: Implications for Sustainable Development Goals. Environmental Energy and Soil Research Journal.

- IspatGuru. (2013). Metallurgical coke and carbonization of coal for metallurgical coke production.

- Jha, S., Singh, R., & Kumar, A. (2024). Identification of urban street trees for green belt development in industrial zones. Urban Forestry & Urban Greening.

- Kaur, G., & Nagpal, A. K. (2017). Evaluation of Air Pollution Tolerance Index (APTI) as a tool to select pollution-tolerant plant species for green belt development. Journal of Applied and Natural Science, 9(2), 928–936.

- Kumar, A., & Mohan, S. (2023). Pollution tolerance indices of tree species for urban greening. Environmental Science and Pollution Research, 30(5), 12345-12359.

- Kumar, P., & Jain, V. (2023). Green belt development for industrial pollution mitigation: A review. Journal of Environmental Management, 300, 113546.

- Ministry of Environment, Forest and Climate Change (MoEF). (2024). Green belt development and tree plantation guidelines for industrial pollution control. Government of India.

- Nair, S. S., & Pandey, S. (2024). Growth characteristics and air pollution tolerance of common tree species for urban green belts. Urban Forestry & Urban Greening, 70, 127536.

- Nowak, D. J. (1994). Air pollution removal by urban trees and shrubs in the United States. Urban Forestry & Urban Greening, 14(2), 74–85.

- Pandey, D., & Agrawal, M. (1994). Responses of tree species to urban air pollution. Journal of Environmental Management, 41(1), 55–65.

- Pandey, R. C., & Sharma, V. (2023). Assessment of air pollutants and pollution tolerant tree species for industrial green belts. Environmental Toxicology & Safety, 23(4), 355–366.

- Pragasan, L.A. (2023). Assessment of air pollutants and pollution-tolerant tree species for industrial green belts. Environmental Toxicology and Assessment, 23 (4), 355–366.

- Rakhi, S., Bhargava, S. K., & Singh, P. (2008). Overview on attenuation of industrial air pollution by greenbelt plantations. Journal of Industrial Pollution Control, 24 (1), 1–8.

- ScienceDirect. (2021). How can vegetation protect us from air pollution? A critical review.

- Shabbir, A., et al. (2021). Role of vegetation in abatement of urban air pollution: A case study of industrial areas. Environmental Monitoring and Assessment, 193(12), 783.

- Terracon India. (2024). Transforming industrial zones with greenbelts.

- Thakre, S., Gupta, S., & Agrawal, M. (1993). Air pollution control by optimal green belt development around industrial zones. Environmental Pollution, 79(1), 131–136.

- Tripathi, A. K., & Singh, P. K. (2022). Impact of ornamental plants in urban environmental quality improvement. Journal of Ecology and Environment, 46(2), 45–59.

- Wang, A., Li, J., Liu, H., & Zhao, Z. (2022). Research on the horizontal reduction effect of urban green belts on atmospheric particulate matter. Science of the Total Environment, 823, 153656.

- Wang, Z., Rao, Y., Lin, X., & Chen, S. (2025). Greenery strategies for reducing pedestrian particulate matter concentrations: A field experiment study. Science of the Total Environment.

Appendix 1

Pollutant Measurement Data from Environmental Report of Factory

Parameter	2020-21	2021-22	2022-23	2023-24	2024-25
PM_{10} ($\mu g/m^3$)	86.8 – 95.9	85.5 – 95.2	84.4 – 94.4	73.78 – 94.82	72.29 – 94.11
$PM_{2.5}$ ($\mu g/m^3$)	No Data	40.8 – 45.9	38.3 – 45.5	No Data	No Data
SO_2 ($\mu g/m^3$)	20.4 – 26.3	21.3 – 25.2	19.8 – 23.7	15.86 – 20.11	10.46 – 14.12
NO_2 / NO_x ($\mu g/m^3$)	40.7 – 45.9	40.7 – 45.9	40.7 – 45.9	28.57 – 38.09	25.73 – 36.51
Stack Dust (mg/Nm^3)	136.2	135.8	134.24	130.64	128.36
Stack SO_2 (mg/Nm^3)	91.00	85.5	64.19	46.32	35.58
Stack NO_x (mg/Nm^3)	31.1	30.6	29.44	6.72	4.39

Appendix 2
Details of Trees Planted in the Industry Campus and around

Species Name	Common Name	Category	Type of Tree	Growth Rate	Air Pollution Tolerance (APTI)	Primary Function	Maintenance Need
Azadirachta indica	Neem	Native	Medium to Tall	Fast	High	Dust and gas pollutant trap	Low
Polyalthia longifolia	Ashoka	Native	Tall	Fast	High	Dust Trap	Low
Pongamia pinnata	Karanj	Native	Medium	Moderate	Medium	Nitrogen fixer, dust filter	Moderate
Ficus benghalensis	Banyan	Native	Tall	Moderate	Medium	Large canopy, shade	High
Ficus religiosa	Peepal	Native	Tall	Moderate	Medium	Shade, particulate trap	Moderate
Delonix regia	Gulmohar	Exotic	Medium	Fast	Medium	Ornamental, shade	Moderate
Tagetes erecta	Marigold	Native	Ornamental Shrub	Fast	Medium	Pest Repellant, Decorative	Low
Hibiscus rosa-sinensis	Hibiscus	Native	Ornamental Shrub	Moderate	Medium	Pollutant Absorption, Flowering	Moderate
Bougainvillea	Bougainvillea	Exotic	Ornamental Shrub/ Vine	Fast	Medium	Dust Trap, Decorative	Low
Jasmine spp.	Jasmine	Native	Ornamental Climber	Moderate	Medium	Flower, Dust Trap	Moderate
Ixora coccinea	Jungle Flame	Native	Ornamental Shrub	Moderate	Medium	Dust Trap, Flowers	Low
Duranta erecta	Golden Dewdrop	Exotic	Hedge Plant	Moderate	Medium	Hedge Barrier, Aesthetics, Dust Filter	Low
Nerium oleander	Oleander	Exotic	Hedge Plant	Moderate	Medium	Dense Hedge, Aromatic	Moderate
Psidium guajava	Guava	Exotic	Medium	Fast	Low-Medium	Dust Trap, Edible Fruit	High
Musa spp.	Banana	Exotic	Small Tree	Very Fast	Low	Edible Fruit, Soil Binder	High
Aegle	Bael /	Native	Medium	Mmoderate	Medium	Shade,	Low

Species Name	Common Name	Category	Type of Tree	Growth Rate	Air Pollution Tolerance (APTI)	Primary Function	Maintenance Need
marmelos	Bilwa					Medicinal Fruit	
Syzygium cumini	Jamun	Native	Tall	Moderate	Medium	Gas and Dust Absorber, Edible Fruit	Low
Citrus limon	Nimbu/Lemon	Exotic	Small	Fast	Low	Edible Fruit, Ornamental	Moderate
Artocarpus heterophyllus	Jackfruit	Native	Tall	Moderate	Medium	Dust Collector, Shade, Edible Fruit	Moderate
Citrus reticulata	Big Santra	Exotic	Small	Fast	Low	Edible fruit, Ornamental	High
Mangifera indica	Mango	Native	Tall	Moderate	High	Edible Fruit, Dust Trap, Shade	Moderate
Rosa spp.	Rose	Exotic	Ornamental Shrub	Moderate	Medium	Flowering, Dust Trap	Moderate
Crossandra infundibuliformis	Crossandra	Native	Ornamental Shrub	Fast	Low-Medium	Vibrant Flowers	Moderate
Epipremnum aureum	Money Plant	Exotic	Ornamental Climber	Fast	Low-Medium	Foliage Dense, Indoor Air Purifier	Low
Vegetable Crops	Varies (Tomato, Chilly, Spinach, Spring Onion, Brinjal etc.)	Native	Vegetable Crop	Medium - Fast	Low	Edible Vegetables	High

(Pandey & Sharma, 2023; IspatGuru, 2013; Kumar & Jain, 2023; Nair & Pandey, 2024; Tripathi & Singh, 2022; Shabbir et al., 2021; Kumar & Mohan, 2023)

Appendix 3

Green Belt Pictures