

**Report as per order of the Hon'ble NGT, Central Zonal Bench,
Bhopal passed on date 16.05.2025 in OA No. 168/2024 Chitrabhan
Singh Rathore & Ors.Vs State of Chhattisgarh & Ors.**

Issue raised in the original application is the non-compliance of the condition of Environmental Clearance (EC) by the project proponent. A committee was constituted under the Hon'ble Tribunals order and was directed to submit the factual and action taken report. The said committee filed its report before the Hon'ble Tribunal. The matter came up for hearing before the Hon'ble Tribunal on date 16/05/2025 and the following instructions were issued –

“1. Issue of non-compliance of the condition of EC has been raised in this application and a committee was constituted with direction to submit the factual and action taken report. The members of the committee visited the site and submitted report. Learned Counsel for the applicant raised three issues:

- i. Plantation and its survival*
 - ii. Construction and maintenance of road, which is under repair or damage.*
 - iii. Issue relating to health condition of villagers and availability of medical facility.*
- 2. The compliance report and list of plantation has been filed by the Learned Counsel for the PP. In spite of the notices CECB has not filed the compliance report or the reply.*
- 3. In view of the above facts CECB & District Forest Officer concerned are directed to verify these things ensure the compliance of conditions and submit the report after verification. PP has to file the compliance report with affidavit before the next date of listing.*

List it on 1st July, 2025.”

The Regional Officer, Regional Office, CECEB, District – Bilaspur (C.G.) along with D.F.O. Champa, District – Janjgir Champa (C.G.) visited the plant side on dates 18/06/2025 and 19/06/2025 to ensure the compliance of the Hon'ble Tribunals order. Following are the findings with respect to compliance of the matters raised by the applicant:-

1) Plantation and its survival: For verifying the fact, the committee has called the records i.e. Environment Clearance and Consent to Operate orders issue to Project Proponent. The committee has perused the terms and condition of Consent to Operate as well as the details of provided in Environment Clearance. As per the terms and conditions of Consent to Operate, the Project Proponent is required to:

- Maintain 50% green belt area with minimum 8500 nos. plantation.
- Maintain a green wall of 20 meters all along the boundary of the plant.
- Maintain a green wall of 40 meters in the railway siding area.
- The green belt must be a three-tier level plantation.

Suggestions for improvement-

1. It was observed that the soil in which plantation has been done lacks porosity and thus it will be better to mix sand in the plantation area so that there is better survival of the plants.
2. It is also advised that spreading of local available grass seeds can be done to maintain a check on soil erosion and increase the aesthetics
3. As one of the issues was that the grazing lands of villagers are lost, some fodder species like Babool, Khair, Banyan etc. can also be planted which can survive the local edaphic and climatic conditions and also provide fodder to local villagers if needed.

Overall, the company has worked on all the aspects as per the directions issued by the Hon'ble Tribunal. It is also mentioned that the aforementioned suggestions may be implemented to form a three-tier green belt which can further the agenda of protection against pollution. The research paper by S. K. Maiti titled "*Selection of plant species for the reclamation of minedegraded land in the Indian context*" along with the plantation photographs in the industry have been annexed as **Annexure-1** with the report to allow the full understanding of the construction of green belt around industries.

2) Construction and maintenance of road, which is under repair or damage: During the visit, it was observed that the approach road which leads to the industry has been repaired and is being maintained. The representative of the project proponent present during the visit informed that the approach road is regularly inspected and maintained by the project proponent. He has also informed that water sprinkling is being carried out on the approach road from the starting point to the end point of the road every day. Copy of the photographs of the approach road taken on the date of visit is attached as **Annexure-2** with this report.

3) Issue relating to health condition of villagers and availability of medical facility: A letter dated 19/06/2025 has been sent to the Primary Health Centre, Village – Sivni, District – Janjgir Champa (C.G.) seeking information from them regarding the complaints of any disease caused because of the operation of the industry. Also, during the visit, the officials of the CECB talked with the villagers of Village – Kanhaibandh. The villagers told that a health camp was organized by the project proponent on date 29/05/2025 and in the camp, no illness has been found to be caused due to pollution.

The Primary Health Centre, Village – Sivni, District – Janjgir Champa (C.G.) have stated in their letter that 14 people are suffering from cough for 2-4 days and 5 people are suffering from allergy since 2-4 days. The PHC also states in its letter that currently all these people are healthy. A copy of the letter dated 19/06/2025, panchnama dated 18/06/2025 and letter of PHC, Village – Sivni, District Janjgir Champa (C.G.) are collectively attached as **Annexure-3** with this report.



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Selection of plant species for the reclamation of mine-degraded land in the Indian context

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Selection of plant species for the reclamation of mine-degraded land in the Indian context

S.K. Maiti, Chandan Shee and Mrinal K. Ghose

Abstract

The increasing trend towards opencast coal mining in India is leading to serious air pollution. This paper examines the sources of air pollution in coal mining areas, and focuses on the role of 'green belts' in checking the dispersion of air pollutants to surrounding areas. It describes the mechanisms for removal of air pollutants. A survey was conducted in the Jharia and Eastern Coalfield areas to identify existing plant communities and to select useful plant species for the control of air pollutants by 'green belts'. The dust collection capacities of the leaves of different trees were estimated, and stomatal size and frequency analysed. The dust-arresting capacities of some plants commonly growing in mining areas were ranked according to their potential. The removal of gaseous pollutants depends on stomatal size and frequency. A uniform scale, the percentage of stomatal coverage, has been calculated for commonly growing plant species, and they have been ranked accordingly to their effectiveness. The higher the stomatal coverage, the better the removal efficiency. Trichomes on the leaf surface were found to be important for capturing dust. Some species were found to increase their stomatal frequency in polluted areas. This paper concludes that selection of plant species should be made on the basis of size of stomata, stomatal frequency and tolerance to specific pollutants. A scheme for the design of 'green belts' for the attenuation of air pollution has been proposed, based on percentage stomatal coverage in leaves and the dust-arresting capacity.

Key words: coal mining, dust, green belt, stomata, tree canopy

INTRODUCTION

India has emerged as the world's third largest coal producing country, after China and the USA. The country's coal reserves are estimated at 70 billion tonnes, which accounts for 5.7% of proven world reserves (Mathur 1996). Indian coal consumption is about 5.5% of the world total. The share of coal as a source of energy in the commercial sector increased to 66% in 1994–95 (Kumar 1995). In India, coal production will have to increase to meet energy demand over the next 20–25 years at the rate of 20–25 Mt/y. The national plan envisages further exploitation of coal resources at a very

rapid rate, which is likely to pose greater environmental problems.

Underground coal mining is less detrimental to the environment than opencast mining. But, due to various problems with underground mines, there has been a trend towards opencast mining (Kumar 1995). Globally, coal accounts for 26% of primary energy consumption, whereas in India it has a share of 46% (Singh 2006). Indian coal production, which was of the order of 380 Mt in 2004–05, is supporting some 83 772 MW of thermal power generation, and with developments being planned for 2010, power generation is expected to increase to 150 000 MW (Singh 2006). More specifically, to meet estimated energy needs, India must produce nearly double the quantity of coal that it is currently mining, as fuel requirements will be some 550 Mt/y (Singh 2006). The increasing trend towards opencast mining, together with the adoption of large-scale

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mechanization, has led to the release of large amounts of dust and gaseous pollutants. In opencast mining, massive quantities of overburden (OB) have to be removed to reach the mineral deposits (Ghose 1989). The operations involved are likely to result in massive discharges of fine particulates from overburden materials. Similarly, the mining operations themselves will involve excavation, size reduction, waste material transportation, loading, stockpiling, etc. These will all release particulate matter. Mine closure operations, which are similar to those involved in mine opening, but are of shorter duration, will also release particulate matter (Ghose and Majee 2000). Since future plans envisage that a large proportion of overall coal production will come from opencast mining, more air pollution problems will be created.

Tree planting is one of the best measures for reducing the air pollution (Maiti and Banerjee 1992; Maiti 1993, 1998; Abbasi *et al.* 2001). This paper focuses on the selection of plant species to control air pollution effectively by developing 'green belts' in coal mining areas.

SOURCES OF AIR POLLUTION DUE TO COAL MINING

The main air pollution problem in a mining area is the presence of particulates, which may be coal, soil or rock dust. Particulates find their way into the atmosphere from wind-scavenged soil surfaces, combustion sources, material transfer points, or other sources at the mine site. Strip-mine air-pollution sources can be divided into two categories: point sources and fugitive sources. Point sources typically include stationary exhaust stacks. In contrast, fugitive sources are open sources, such as the exposed soil of OB, and coal (Ghose and Majee 2001). During dry and windy conditions, the surface soil is scavenged by wind, causing particulate matter (dust) to be suspended and transported downwind. A subset of point sources of particulates would include line sources and mobile sources. Most important are the identification and quantification of dust emissions at the mine site.

Heavy earth-moving machinery (HEMM) on haul roads has been identified as the most prolific source of fugitive dust, and can contribute as much as 80% of total dust. Cowherd *et al.* (1979) estimated that about

50% of the total dust is released during dumper truck movements on unpaved haul roads, while 25% arises during loading and unloading operations. Chadwick *et al.* (1987) estimated that 0.02% of coal is lost during loading and unloading. Nair and Singh (1990) estimated that road dust contains more than 4% of respirable dust.

Another major source of fugitive dust is wind erosion from stockpiles. Jacko (1983) has given estimates of fugitive dust from mining operations. In opencast mining, workers are exposed to concentrations ranging from 3–5 mg/m³ in coalfaces to 1–2 mg/m³ in overburden faces. After haul roads, drilling is perhaps the next most important source of fugitive dust. During drilling in overburden benches, the dust concentration varies between 20 and 25 mg/m³, and in coal benches it varies between 15 and 30 mg/m³.

MECHANISMS: FOR REMOVAL OF AIR POLLUTANTS BY 'GREEN BELTS'

A 'green belt' is the mass planting of pollution-tolerant trees (evergreen and deciduous) in an area, for the purpose of minimizing air pollution by filtering, intercepting and absorbing pollutants in an effective manner to improve the environment (Roy and Sharma 1997; Abbasi *et al.* 2001). The pollutants are transferred from the atmosphere to vegetation by the combined forces of diffusion and flowing air movements (Smith 1981). Once in contact with plants, gases may be bound or dissolved on exterior surfaces or taken up by the plant via stomata. If the surface is wet and pollutants are water-soluble, then they are removed by the diffusion process. When the plant is dry, or in the case of gases with low solubility, air movement is assumed to be an important mechanism. The rate of gaseous pollutant removal depends on the solubility of pollutants in water and is reported as following the order: HF > SO₂ > Cl > NO₂ > O₃ > PAN > NO > CO (Hill 1971; Bennett and Hill 1975).

Trees are to be selected based on location, availability and sustainability given the climate; and on the type of pollutants and their intensity. Trees with compact branching, closely arranged leaves, broad leaves of simple elliptical and hairy structure, shiny or waxy leaves and high proline content are suitable for arresting dust pollutants (Maiti 1993). All the plant parts act

as sinks; leaves intercept 60–90%; petioles (leaf stalks) 3–30%; and stems 4–14% (Smith 1981). The natural sink processes are precipitation, chemical reaction, sedimentation and absorption. Research into the criteria for selection of plant species for gaseous pollutant attenuation in India is very sparse. The Central Pollution Control Board (CPCB) (Anon. 2000) has suggested the following criteria for selection of plant species for removal of particulate pollutants:

- (i) Height and spread of crown;
- (ii) Arrangement of leaves (phyllotaxy);
- (iii) Abundance of surfaces on bark and foliage, through:
 - roughness of bark
 - epidermal outgrowth on petioles
 - abundance of auxiliary hairs (trichomes)
 - stomata protected (hairs, wax, etc.).

In the present investigation, stomatal features of 51 tree species commonly growing in mining areas were studied and ranked according to their ability to absorb gases and dust.

DATA COLLECTION METHODS

(a) Green belt characterization

Two mining areas were selected for the study of green belts (Table 1). One area was the Jharia coalfield, where most of the plants were exotic in nature. The other area was in the Eastern coalfield, where indigenous plants were planted for the development of green belts. The trees growing in the green belt were classified as evergreen or deciduous, having simple or compound leaves (Maiti 1998).

Frequency indicates the homogeneity of dispersion of the individual tree species in the green belt, and is calculated as follows (Maiti 1993):

$$\text{Frequency (\%)} = \frac{\text{No. of particular species}}{\text{No. of quadrates studied}} \times 100$$

$$\text{Relative frequency (\%)} = \frac{\text{Frequency of species}}{\text{Sum of frequency of all species}} \times 100$$

Aerial height was measured by scale and expressed

in m. Bole height (expressed in m): height of stem from ground to first branch appearing on the stem. Average canopy height (m) = total height – bole height.

(b) Measurement of dust on the leaf surface

The deposition of dust depends on leaf morphology (including area of lamina), proximity of dust sources, height of leaf and type of tree species – whether evergreen or deciduous. The dust deposition on leaves can be expected to be at a maximum during winter and summer in a tropical climate (i.e. November to March), thus the field studies were conducted in the period November to March, and continued for three years. The trees growing in the green belt were classified as evergreen or deciduous, having simple or compound leaves (Maiti 1998). The following categories of plants were considered during the survey:

- Evergreen with simple leaves – nine plants;
- Evergreen with compound leaves – six plants;
- Deciduous with simple leaves – three plants;
- Deciduous with compound leaves – four plants;
- Shrubs and herbs.

In the case of trees greater than 5 m in height, ten fully mature leaves were collected at a height of 1.5–2.1 m. For herbaceous species, leaves were collected at various heights above ground level. Collected leaf samples were put in sealed polythene bags and brought to the laboratory, and dusts deposited on the leaf surface were washed with distilled water. Polythene bags were also washed with distilled water. The suspension was filtered by GFIC filter paper, and the filter papers were dried at 100–105°C. The leaf area was measured using a leaf area meter (Systemic model). Dust concentration was expressed in g/m² of the leaf area:

$$\text{Concentration of dust (g/m}^2\text{)} = \frac{\text{Final weight of filter paper (g)} - \text{initial weight of filter paper (g)}}{\text{Area of leaf surface, m}^2}$$

(c) Selection of plants for leaf epidermal features study

Fifty-one tree species comprising tall, medium and dwarf types were selected for the study and were categorized on the basis of simple and compound leaves. The leaves were collected from the plants growing in the mining areas. Leaves were picked from the ends of

Table 1. Characteristics of green belt in mining areas

Tree	Frequency (%)	Aerial height, m (DBH, cm)	Bole height (m)	Average canopy height (m)
Jharia Coalfield				
1. <i>Acacia auriculiformis</i>	53–100	4–10 (5–8)	1.4–4.4	2.7–6
2. <i>Cassia siamea</i>	22–50	4–10.5 (4–10)	1.2–6	3–4.5
3. <i>Leucaena leucocephala</i>	40–42	9–9.5 (6–7)	4–4.3	5–5.4
4. <i>Gmelina arborea</i>	5–6	4–5 (4–5)	2–2.5	2–2.5
5. <i>Dalbergia sissoo</i>	3–6	3.7–10.5 (3–7)	1.7–2.2	2–8.3
Eastern Coalfield				
1. <i>Acacia auriculiformis</i>	34–100	7–22 (5–8)	1.5–4.3	5–17
2. <i>Albizia lebbek</i>	1–1.3	4.8–5.9 (12)	1.8–2	3–3.7
3. <i>Cassia siamea</i>	1–1.5	4.2–10.5 (20)	1.2–6	3–4.5
4. <i>Dalbergia sissoo</i>	3.5–4	4.5–5 (3)	1.7–2	3–3.5
5. <i>Eucalyptus</i>	4–48	9–13 (5–10)	3–7	6–6.5
6. <i>Madhuca indica</i>	15–52	8–22 (10–15)	2–2.2	6–20
7. <i>Shorea robusta</i>	10–50	7–23 (8–15)	2–3.3	5–20
8. <i>Terminalia arjuna</i>	3–4	12–12.5 (8–9)	2–2.5	10–10.5

branches (leaving the upper three leaves from the tip) and another leaf from the middle of the branch. Other sets of leaves were collected from the base of the same branch. In the case of small trees, leaves were collected at 1.5 m from ground level.

(d) Study of stomata by peeling method

To study stomatal and trichome morphology, the peeling method was followed using quick-fix adhesive. A thin layer of adhesive was applied in-between side-veins of the upper, middle and lower portions of laminae. The mid-rib portion was avoided. For stomatal study, the lower surface was considered, whilst for trichome study both surfaces were considered. After application of adhesive, sufficient time was allowed for drying. The thin film of adhesive was peeled and examined under a compound microscope (Olympus BX 60 fitted with a digital camera) with on-line image transferring facilities. The captured image was analysed by image analysis software (Olympus Micro Image Lite Version 4.0).

(e) Stomatal size and frequency

The number of stomata and epidermal cells per unit area (mm^2) were counted under different magnifications (215 \times , 450 \times and 860 \times). Lower magnification was used for counting the stomatal numbers, and higher magnification for stomatal size measurements. The number of stomata present in one microscopic field (area of vision) was captured. The area of microscopic

field under 215 \times was 0.2961 mm^2 , at 430 \times it was 0.074 mm^2 , and at 860 \times it was 0.0184 mm^2 . For each leaf, 20 observations were taken. The stomatal frequency was calculated as follows:

$$\text{(i) Stomata frequency (mm}^2\text{)} = \frac{\text{No. of stomata present}}{\text{Area of microscopic field (mm}^2\text{)}}$$

$$\text{(ii) Stomata coverage per unit area of leaf (\%)} = \text{stomatal frequency (no. of stomata opening/mm}^2\text{ of leaf area)} \times \text{stomatal size (\mu m}^2\text{)} \times 10^6 \times 100.$$

The number of trichomes/unit area of leaf (mm^2) was counted to calculate the trichome frequency. The morphology of the trichomes was studied by measuring their size, shape, length and breadth.

RESULTS AND DISCUSSION

Table 2 shows that the dust collecting efficiency of *Alstonia scholaris* is highest (28 g m^{-2}), followed by *Artocarpus integrifolia* (18 g m^{-2}), *Ficus cunea* (16 g m^{-2}) and *Mangifera indica* (15 g m^{-2}). The dust collection efficiencies of *Mangifera* as studied by Rao (1971), at a coal loading and unloading facility near Varanasi, India in the month of January were in the range of 130–150 g m^{-2} . However, in the present study, a maximum of 32 g m^{-2} was found.

Table 2. Dust retaining capacity of evergreen trees

Botanical name	Min. dust (g/m ²)	Max. dust (g/m ²)	Avg dust (g/m ²)	Rank
Simple leaf				
1. <i>Alstonia scholaris</i> (n = 30)	5.2	56.3	28.23	1
2. <i>Artocarpus integrifolia</i> (n = 15)	14.0	23.0	18.24	2
3. <i>Ficus cuneata</i> (n = 10)	16.2	16.4	16.33	3
4. <i>Mangifera indica</i> (n = 20)	4.0	32.0	15.75	4
5. <i>Ficus benghalensis</i> (n = 16)	3.1	28.7	16.99	5
6. <i>Acacia auriculiformis</i> (n = 25)	5.0	27.5	12.84	6
7. <i>Eucalyptus</i> sp. (n = 20)	4.4	24.3	12.21	7
8. <i>Eugenia jambolana</i> (n = 12)	5.0	15.3	11.62	8
9. <i>Polyalthia longifolia</i> (n = 20)	2.6	18.0	11.13	9
Compound leaves				
1. <i>Gmelina arborea</i> (n = 15)	3.2	29.7	19.8	1
2. <i>Cassia siamea</i> (n = 20)	4.9	27.0	14.7	2

(n = number of leaf samples)

Table 3. Dust retaining capacity of deciduous trees

Botanical name	Min. dust (g/m ²)	Max. dust (g/m ²)	Avg dust (g/m ²)	Rank
Simple leaf				
1. <i>Ficus religiosa</i> (n = 25)	14.7	41.0	19	1
2. <i>Butea frondosa</i> (n = 15)	16.0	34.0	13	3
3. <i>Psidium guava</i> (n = 15)	12.0	33.0	16	2
4. <i>Zizyphus mauritiana</i> (n = 15)	6.0	18.0	11.2	4
Compound leaves				
1. <i>Dalbergia sissoo</i> (n = 8)	8.0	16.3	12.5	1
2. <i>Cassia fistula</i> (n = 10)	6.0	15.0	8.3	2
3. <i>Melia azedarach</i> (n = 10)	2.5	12.0	5.9	3
4. <i>Melia azadirachta</i> (n = 8)	2.1	8.2	5.2	4

(n = number of leaf samples; s.d = standard deviation)

Table 4. List of shrubs growing in green belt

Botanical name	Min. dust (g/m ²)	Max. dust (g/m ²)	Avg dust (g/m ²)	Rank
1. <i>Ipomoea carnea</i> (n = 15)	12.2	66.2	36.5	1
2. <i>Calotropis procera</i> (n = 10)	12.6	64.9	43.6	2
3. <i>Hyptis suaveolens</i> (n = 10)	5.6	46.0	28.7	3
4. <i>Lantana camera</i> (n = 15)	3.1	26.4	17.3	4
5. <i>Hibiscus rosa-sinensis</i> (n = 12)	4.6	20.2	12.9	5

(n = number of leaf samples)

Dust collection efficiency of deciduous plants

Out of eight deciduous trees studied, trees having a simple leaf were better dust collectors than those with compound leaves, as shown in Table 3. Of all compound leaf plants studied, *Dalbergia sissoo* showed the maximum dust-arresting capacity because of hairy out-growth on the leaf surface.

Dust collection efficiency of shrubs

Most of the shrubs growing in the green belts were

found to retain more dust than the tree species, as shown in Table 4. Shrubs like *Ipomoea* and *Calotropis* were found to be superior to other shrubs.

Selection of plant species based on stomatal characteristics

(a) Plants with simple leaves

In general, it was found that when stomatal frequency (SF) increases, size of stomata decreases. Leaves with higher SF as well as larger stomata, are better for the

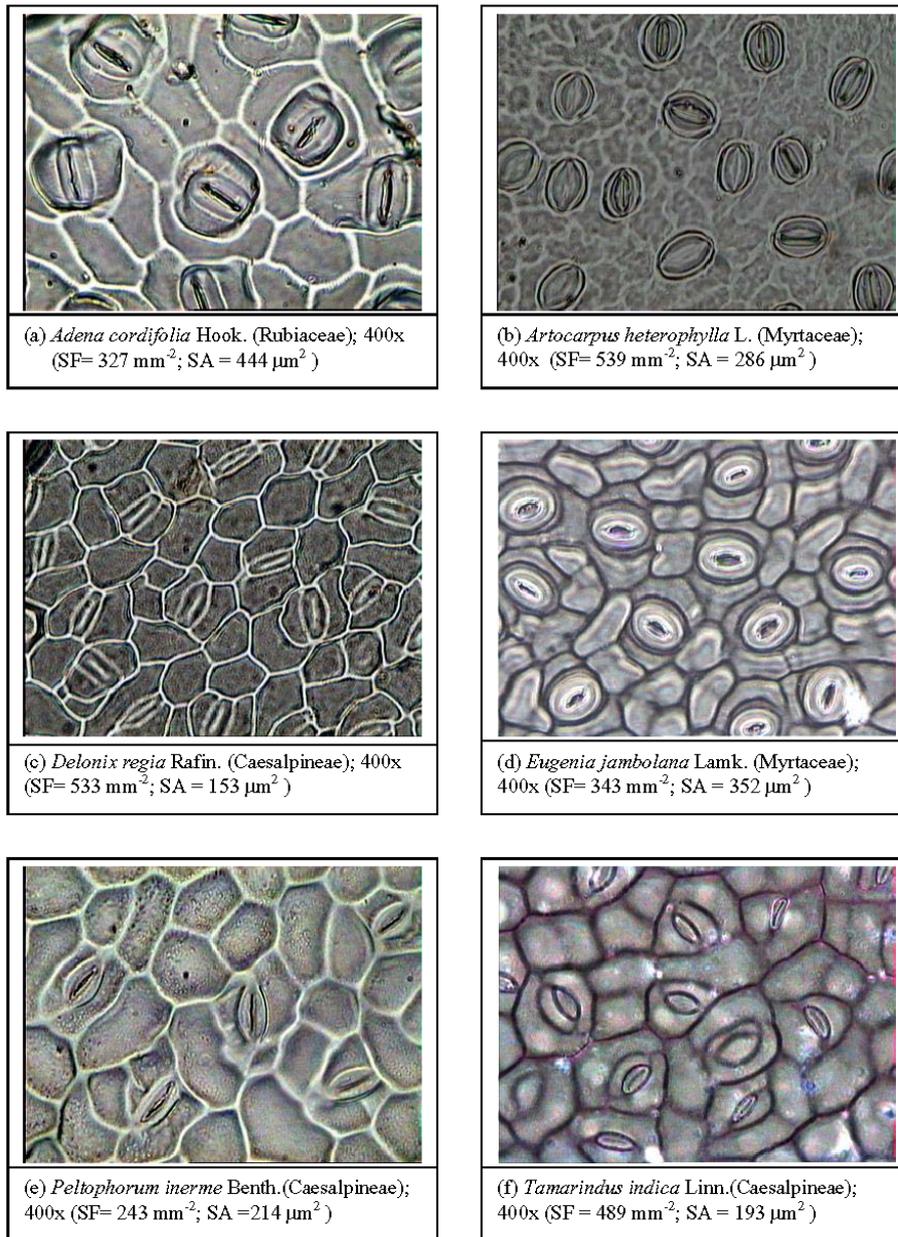


Figure 1. Different types of stomatal morphology (frequency, size and shape) of simple-leaved tree species (a, b, d) and compound-leaved tree species (c, e, f). The lower the stomatal frequency the greater the stomatal size and vice versa. (SF = stomatal frequency; SA = stomatal area)

attenuation of gaseous pollutants (Figure 1). Therefore, the percentage of stomatal coverage in each tree leaf was calculated ($SF \times \text{size of stomata}$), and ranked accordingly (Table 5). For example, *Shorea robusta* had very high SF ($616/\text{mm}^2$) but very small stomatal size ($153 \mu\text{m}^2$), and ranked 18th. Likewise, the largest stomata were recorded in *Saraca indica* ($799 \mu\text{m}^2$), but stomatal frequency was low ($149/\text{mm}^2$), thus it was

ranked thirteenth.

Of 29 plants studied, some of the best were: *Ficus benghalensis* (stomatal coverage 19.7%), *Terminalia arjuna* (17.5%), *Ixora coccinea* (17.3%), *Adina cordifolia* (14.5%), *Polyalthia longifolia* (13.5%), *Bougainvillea* (13.4%), *Anthocephalus cadamba* (13.2%) and *Eugenia jambolana* (12%). Preference should be given

Table 5. Characteristics of stomata in simple leaf

Sl no.	Name	Stomatal frequency/mm ²	Rank	Stomata area (µm ²)	Rank	% of stomatal area	Rank	Trichomes (no./mm ²)	Height
1.	<i>Anthocephalus cadamba</i>	638	1	207	21	13.20	9	A	Tall
2.	<i>Shorea robusta</i>	616	2	153	28	9.42	18	A	Tall
3.	<i>Mangifera indica</i>	556	3	224	22	12.45	11	A	Medium
4.	<i>Artocarpus heterophylla</i>	539	4	304	15	16.38	4	A	Medium
5.	<i>Anacardium occidentale</i>	529	5	286	18	15.12	5	A	Dwarf
6.	<i>Ficus retusa</i>	491	6	178	27	8.73	20	A	Tall, big
7.	<i>Ficus benghalensis</i>	477	7	413	8	19.70	1	A	Tall, big
8.	<i>Lagerstroemia flos-reginae</i>	475	8	207	23	9.83	17	A	Medium
9.	<i>Terminalia arjuna</i>	473	9	369	10	17.45	2	A	Tall
10.	<i>Acacia auriculiformis</i>	471	10	166	28	7.82	24	A	Medium
11.	<i>Ficus infectoria</i>	433	11	186	26	8.05	22	A	D-medium
12.	<i>Ficus hispida</i>	429	12	187	25	8.02	23	23	D-medium
13.	<i>Michelia champaca</i>	413	13	318	14	13.13	10	77	Medium
14.	<i>Swietenia macrophylla</i>	411	14	258	19	10.64	15	A	Medium
15.	<i>Tectona grandis</i>	395	15	188	24	7.42	25	A	Tall
16.	<i>Thevetia nerifolia</i>	393	16	303	16	11.90	14	A	Dwarf
17.	<i>Bauhinia purpurea</i>	345	17	110	30	3.79	28	76	Medium
18.	<i>Eugenia jambolana</i>	343	18	352	12	12.07	12	A	Tall
19.	<i>Ixora coccinea</i>	331	19	523	4	17.31	3	A	Dwarf
20.	<i>Adina cordifolia</i>	327	20	444	6	14.51	6	A	Tall
21.	<i>Polyalthia longifolia</i>	306	21	441	7	13.49	7	A	Tall
22.	<i>Eucalyptus</i>	299	22	297	17	8.88	19	A	Tall
23.	<i>Bauhinia vahlii</i>	249	23	138	29	3.43	29	74	Dwarf
24.	<i>Tagetes patula</i>	215	24	405	9	8.70	21	A	Dwarf
25.	<i>Ficus religiosa</i>	186	25	554	3	10.30	16	A	Tall, big
26.	<i>Madhuca indica</i>	159	26	454	5	7.21	26	A	Tall
27.	<i>Mimusops elengi</i>	151	27	361	11	5.45	27	A	Tall
28.	<i>Saraca indica</i>	149	28	799	2	11.90	13	A	D-medium
29.	<i>Bougainvillea</i>	135	29	991	1	13.37	8	A	Dwarf

d-medium = dwarf-medium

to these plants during development of green belts in mining areas.

(b) Plants with compound leaves

Maximum SF was observed in *Aegle marmelos* (600/mm²), followed by *Spathodea campanulata* (564/mm²), *Samanea saman* (537/mm²), *Delonix regia* (533/mm²), *Butea frondosa* (509/mm²), etc. (Table 6). There was not much difference in terms of SF between simple- and compound-leaved plants. However, stomatal size was small in compound-leaved plants compared with that of simple-leaved plants. The greatest stomatal size was recorded in *Bombax malabaricum* (485 µm²), followed by *Murraya koenigii* (341 µm²), *Millingtonia* (318 µm²), *Azadirachta indica* (296

µm²), etc. (Table 6). The percentage of stomatal coverage was also found to be lower in compound-leaved plants. Some of the best plants in the compound-leaved category were: *Millingtonia* (14.6%), *Azadirachta indica* (12.5%), *Bombax malabaricum* (11.3%), *Aegle marmelos* (9.66%), *Samanea saman* (9.2%), *Delonix regia* (8%), *Spathodea* (7.8%), *Murraya koenigii* (7.2%), *Embllica officinalis* (6.9%), and *Cassia fistula* (6.7%). These tree species should be given priority for the reclamation of degraded mine lands, because of their higher stomatal frequency and coverage.

Trichomes

Trichomes capture dust and act as a dust sink. Of 51 plants studied, only twelve have trichomes. As the sea-

son progresses, the trichomes are reduced in size by 'weathering' and are occasionally completely broken off (Smith 1981). Generally, greater leaf surface roughness increases particle capture efficiency for particles approximately 5 μm or less in diameter. Trichomes and leaf veins are principal contributors to surface roughness.

Trichomes may be present on both the upper and lower surfaces, but the number of trichomes on the upper surfaces was found to be less than on the lower surfaces. Maximum trichome density was recorded as follows: *Cassia fistula* (260 mm^{-2}); *Cassia siamea* (127 mm^{-2}); *Delonix regia* (122 mm^{-2}); *Dalbergia sissoo* (79 mm^{-2}); *Michelia champaca* (77 mm^{-2}); *Bauhinia* (75 mm^{-2}), *Psidium guava* (60 mm^{-2}), *Ailanthus*

excelsa (57 mm^{-2}), *Peltophorum inerme* (33 mm^{-2}) and *Aegle marmelos* (33 mm^{-2}). Trichomes are of different shape and size. In *Cassia fistula*, trichomes are 'curling' only on the upper surface, but on the lower they are 'straight'. In *D. sissoo*, the average length of trichomes was 236 μm , whereas in *Cassia siamea* it was only 61 μm .

EFFECTS OF AIR POLLUTION ON STOMATAL FREQUENCY AND SIZE IN MINING AREAS

In general, different plants have different degrees of resistance to particulates as well as gaseous pollutants (Maiti and Banerjee 1992). Three commonly growing large roadside tree species were chosen to study the

Table 6. Characteristics of stomata in compound leaves

Sl no.	Name	Stomatal frequency/ mm^2	Rank	Stomata area (μm^2)	Rank	% of stomatal area	Rank	Stomatal index	Height	Trichomes, no./ mm^2
1.	<i>Aegle marmelos</i>	600	1	161	12	9.66	4	24	Medium	33
2.	<i>Spathodea campanulata</i>	564	2	138	17	7.78	7	24.84	Tall	A
3.	<i>Samanea saman</i>	537	3	171	11	9.18	5	15.64	Tall, big	A
4.	<i>Delonix regia</i>	533	4	153	13	8.15	6	14.4	Medium	122
5.	<i>Butea frondosa</i>	509	5	124	19	6.31	11	29.43	Dwarf-medium	A
6.	<i>Tamarindus indica</i>	489	6	93	22	4.54	17	18.4	Tall	A
7.	<i>Millingtonia hortensis</i>	459	7	318	4	14.60	1	18.11	Tall	A
8.	<i>Albizia lebbek</i>	455	8	103	20	4.68	16	19.72	Tall	A
9.	<i>Azadirachta indica</i>	421	9	296	5	12.46	2	29.2	Tall	A
10.	<i>Melia azedarach</i>	397	10	129	18	5.12	15	23.5	Medium	A
11.	<i>Cassia siamea</i>	341	11	101	21	3.44	20	21.2	Medium	127
12.	<i>Pithecolobium dulce</i>	307	12	183	10	5.62	13	–	Tall	A
13.	<i>Dalbergia sissoo</i>	307	13	141	15	4.33	18	18.72	Medium	122
14.	<i>Embllica officinalis</i>	273	14	253	7	6.90	9	11.62	Medium	A
15.	<i>Ailanthus excelsa</i>	261	15	236	1	6.16	12	13.01	Medium	57
16.	<i>Cassia fistula</i>	257	16	260	6	6.68	10	20	Medium	260
17.	<i>Jacaranda mimosaeifolia</i>	255	17	150	14	3.82	19	19	Medium	A
18.	<i>Peltophorum inerme</i>	243	18	214	8	5.20	14	16.7	Medium-tall	33
19.	<i>Bombax malabaricum</i>	233	19	485	2	11.30	3	–	Tall	A
20.	<i>Pongamia pinnata</i>	223	20	140	16	3.12	22	25	Medium-tall	A
21.	<i>Murraya koenigii</i>	211	21	341	3	7.20	8	10.3	Medium	A
22.	<i>L. leucocephala</i>	159	22	201	9	3.20	21	–	Medium	A

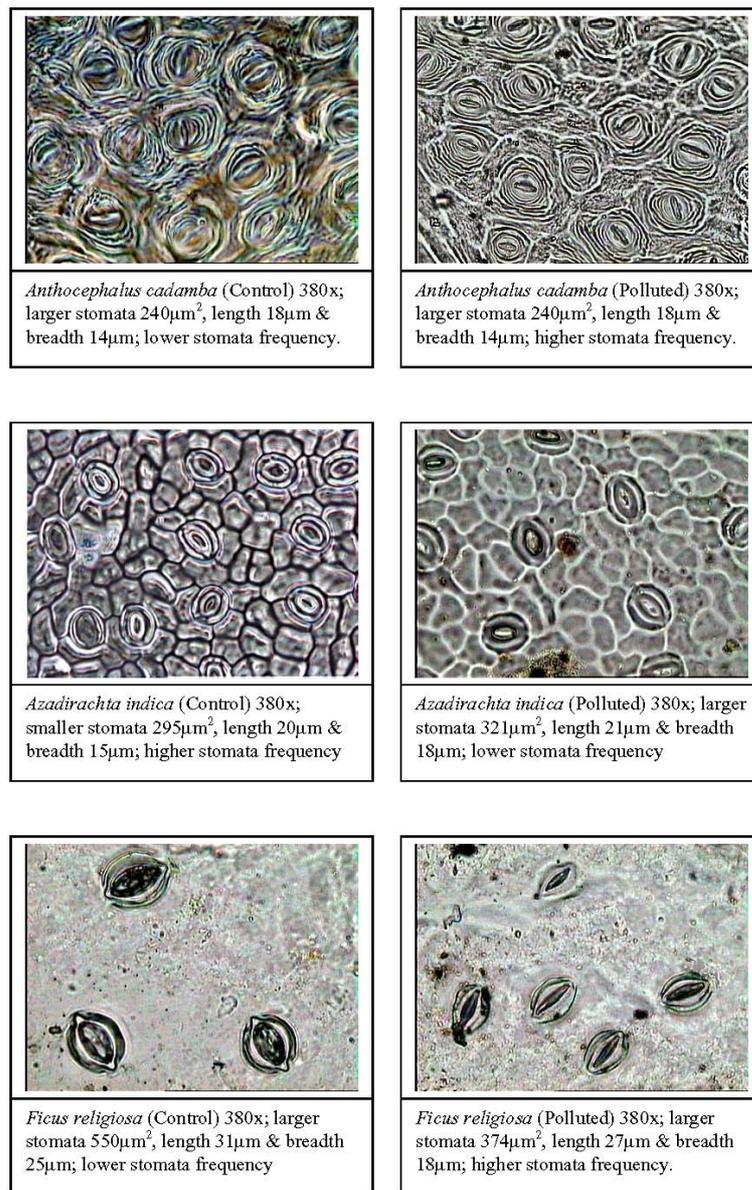


Figure 2. Effects of air pollution on stomata of tree species (*Anthocephalus cadamba*, *Azadirachta indica* and *Ficus religiosa*) growing in mining areas (polluted) and non-mining areas (control)

effects of pollutants on stomatal frequency and size (Figure 2). In the case of *Ficus religiosa* (pipal tree) the SF was found to be higher in the polluted area than in the non-polluted area; however, though SF increased to 23%, stomatal size, length, breadth, and stomatal coverage in leaves decreased. A similar trend was found in *Anthocephalus cadamba*, whereas *Azadirachta indica* (Margosa tree) responded in the opposite manner. The *A. indica* plants growing in the polluted area showed

higher coverage than in the non-polluted area. This indicates that *A. indica* is more tolerant than to *F. religiosa* and *A. cadamba*.

The plant species to be chosen for green belts are as follows (outer to inner side of green belt):

- (i) Dwarf trees with round canopy (spacing: 2 m \times 2 m): *Ixora coccinea*; *Bougainvillea*; *Ficus infectoria*; *Thevetia nerifolia*; *Alstonia*; *Acacia arabica*; *Anacardium occidentale*.

Table 7. Effects of pollution on stomatal frequency and structure

Plant	Location	Stomatal frequency/mm ²	Area (μm^2) mean \pm s.d	Length (μm) mean \pm s.d	Breadth (μm) mean \pm s.d	Leaf coverage (%)
<i>F. religiosa</i> (n = 200)	Polluted	231 \pm 8.5 (199 – 273)*	393.6 \pm 47.2 (352 – 473)	28.03 \pm 1.8 (25 – 32)	19 \pm 1.25 (16 – 21)	9.11
	Control	187 \pm 12 (168 – 209)	554.8 \pm 62 (494 – 663)	31.78 \pm 1.96 (29 – 35)	23.43 \pm 2.2 (22 – 27)	10.36
<i>A. cadamba</i> (n = 200)	Polluted	749 \pm 83 (658 – 900)	155 \pm 27 (141 – 174)	15.67 \pm 1.6 (14.6 – 17.5)	12.11 \pm 1.5 (12.1 – 14)	11.61
	Control	638 \pm 27 (618 – 672)	207 \pm 19 (183 – 234)	17.92 \pm 1.5 (16 – 20)	14.4 \pm 0.7 (13.6 – 15.6)	13.20
<i>Azadirachta indica</i> (n = 200)	Polluted	407 \pm 41.5 (336 – 484)	321 \pm 38.64 (249 – 377)	21.2 \pm 1.7 (19.3 – 24.1)	18 \pm 0.8 (17 – 19.3)	13.06
	Control	422 \pm 42.6 (376 – 497)	295 \pm 42 (258 – 399)	21.7 \pm 1.7 (19.6 – 24.2)	15.16 \pm 1.13 (13.4 – 17.2)	12.45

*(199–273; minimum–maximum) (n = number of leaf samples; s.d. = standard deviation)

- (ii) Medium-height trees (spacing: 4 m \times 4 m): *Adina cordifolia* (stomatal coverage 14.5%); *Polyalthia* (13.5%); *A. indica* (12.5%), *Lagerstroemia* (9.83%); *Aegle marmelos* (9.66%); *Murraya koenigii* (7.2%); *Emblia officinalis* (6.9%); *Ailanthus* (6%); *Cassia fistula* (6.7%); *Terminalia arjuna* (17.5%); *Dalbergia sissoo* (4.3%); *Melia azedarach* (5%).
- (iii) Tall tree (spacing: 6 m \times 6 m): *Millingtonia* (14.6%); *Anthocephalus cadamba* (13.2%); *Eugenia* (12%); *A. indica* (12.5%); *Bombax malabaricum* (11.3%); *Spathodea* (7.8%); *Samanea saman* (9.2%).
- (iv) In addition to the above species, other species are also to be selected, based on the ranking. Further study is needed for identification of additional pollution-tolerant species as well as those with a high stomatal percentage, such as *A. indica*.

CONCLUSIONS

Green belt is an effective and economic means of mitigating air pollution and remains effective for a long period of time. It is the canopy which acts as a sink for gaseous air pollutants. The limitations in green belt development observed during the study were: (i) the

diversity of tree species was not considered; (ii) monoculture plantation was widely practised; and (iii) plant density was not normal, being either too high or too low. As a result, bole height (branchless tree trunk) was very short. It is suggested that plant species selection for the construction of green belt should be made on the basis of stomata characteristics, and an in-depth study is essential. The study reveals that the removal of gaseous pollutants depends on stomatal frequency and size. In some species, stomatal frequency was found to increase in polluted areas. Selection of plant species should be made on the basis of size of stomata, stomatal frequency, stomatal coverage, and tolerance to specific pollutants. The methodology adopted for the study may form the basis of guidelines, and the scheme proposed for designing green belt for attenuation of air pollution will be useful on an industrial scale for various sites.

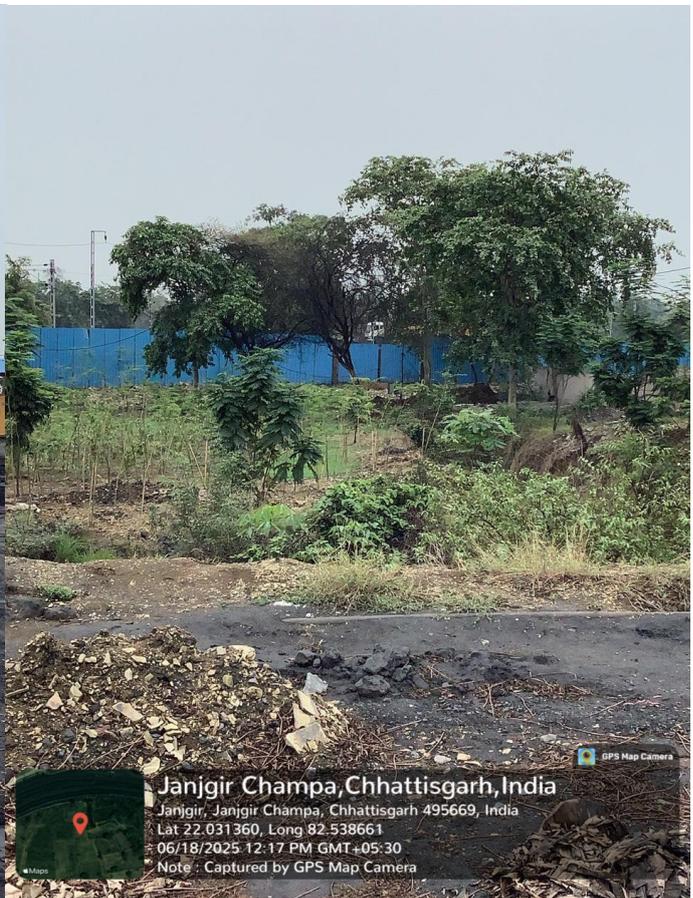
ACKNOWLEDGEMENTS

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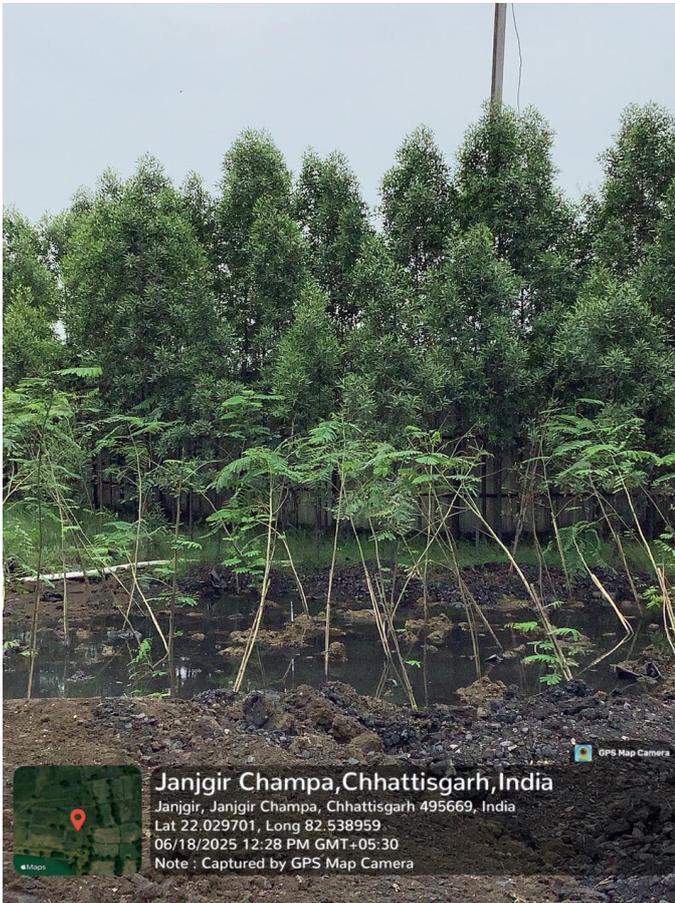




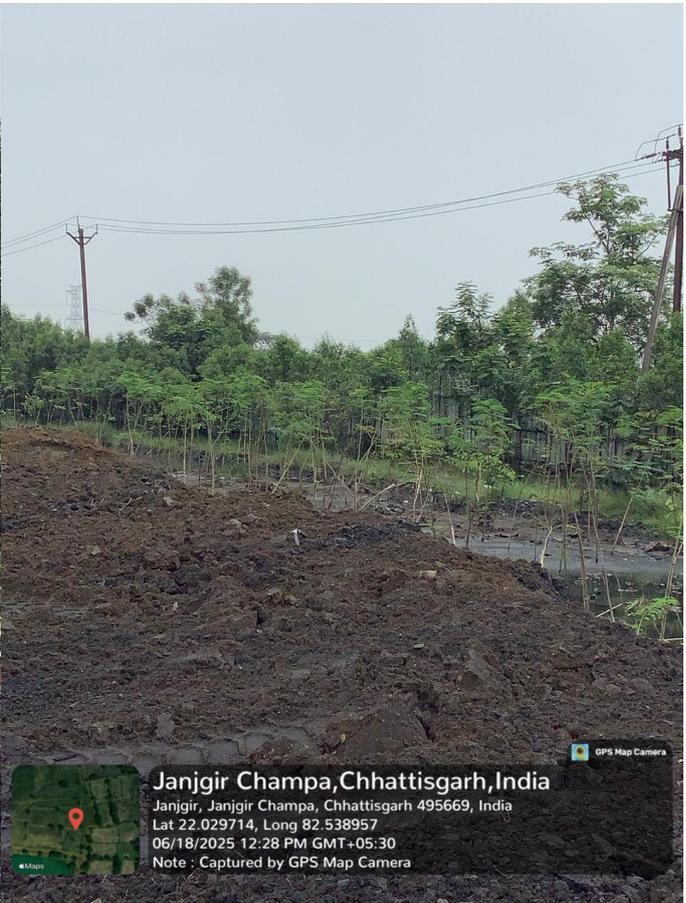
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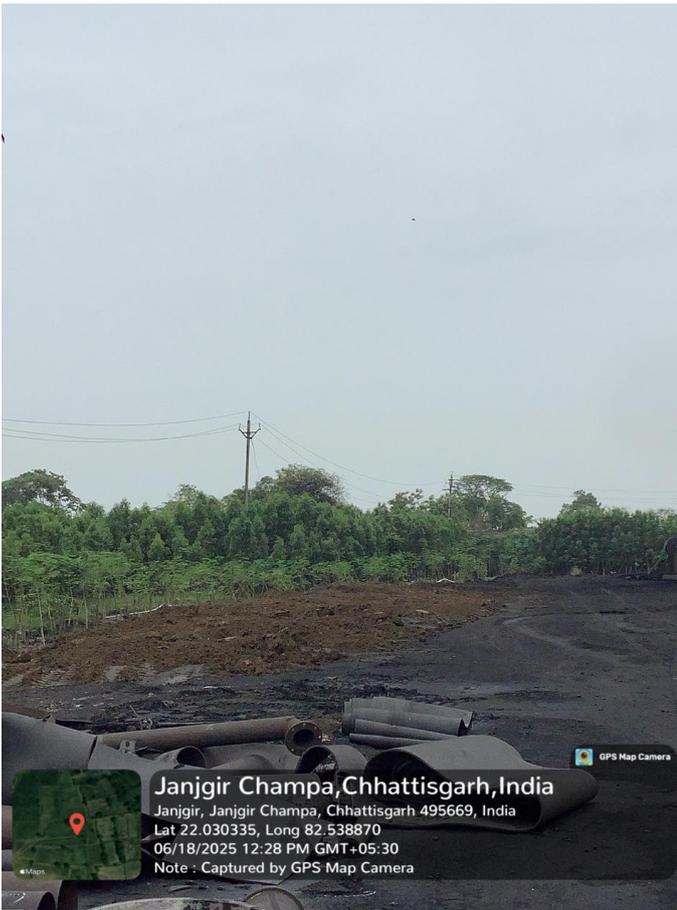
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क्षेत्रीय कार्यालय,

छत्तीसगढ़ पर्यावरण संरक्षण मण्डल,

व्यापार विहार पं. दीनदयाल उपाध्याय पार्क के पास, बिलासपुर (छ.ग.)

e-mail: cecb.robilaspur@gmail.com, Ph. No. 07752-261172

क्रमांक 181 / क्षेत्रा. / तक. / छ.ग.प.सं.मं. / 2025

बिलासपुर, दिनांक : 19/06/2025

प्रति,

प्रभारी,

प्राथमिक स्वास्थ्य केन्द्र,

ग्राम-सिवनी, तहसील-जांजगीर,

जिला-जांजगीर-चांपा (छ.ग.)

विषय :- मेसर्स महावीर कोल वॉशरीज प्राईवेट लिमिटेड, ग्राम-कन्हाईबंद, तहसील-जांजगीर, जिला-जांजगीर-चांपा (छ.ग.) के प्रदूषण से ग्राम-कन्हाईबंद के ग्रामीणों में स्वास्थ्य समस्या के संबंध में।

संदर्भ :- माननीय NGT भोपाल के OA प्रकरण क्रमांक 168/2024 के आदेश दिनांक 16/05/2025

—:00:—

उपरोक्त विषयांतर्गत संदर्भित पत्र के परिपेक्ष्य में लेख है कि मेसर्स महावीर कोल वॉशरीज प्राईवेट लिमिटेड, ग्राम-कन्हाईबंद, तहसील-जांजगीर, जिला-जांजगीर-चांपा (छ.ग.) के पर्यावरण प्रदूषण से संबंधित ग्राम-कन्हाईबंद के ग्रामीणों में विगत वर्ष स्वास्थ्य संबंधी बीमारी/समस्या यदि दर्ज हो तो, जानकारी इस कार्यालय को तत्काल उपलब्ध कराने की कृपा करें।

क्षेत्रीय अधिकारी

क्षेत्रीय कार्यालय,

छत्तीसगढ़ पर्यावरण संरक्षण मण्डल

बिलासपुर (छ.ग.)

५

मंडल मुख्यालय के पत्र क्र. 2246 दि. 21/05/25 के
 अनुक्रम में आज दिनांक 18/06/25 को ग्राम-
 कर्छवांड़- जिला- जांजगीर-पांचा (दुर्गा) के
 ग्रामवासियों के स्वास्थ्य स्तर/स्थिति का
 निरीक्षण किया गया। निरीक्षण दौरान उपस्थित
 ग्रामवासियों द्वारा बताया गया कि मेडर्स
 महावीर कोल कॉलेज प्रा. लि. ग्राम कर्छवांड़
 बह- जांजगीर जिला- जांजगीर-पांचा द्वारा
 29/05/2025 को हेल्थ शिविर का आयोजन
 करवाया गया था, तथा उक्त शिविर में
 ग्रामवासियों के जांच (स्वास्थ्य) में प्रदूषण से
 होने वाली स्वास्थ्य संबंधी समस्या/बिमारी
 नहीं पाई गई।

उपस्थित ग्रामवासियों के नाम

एवं हस्ताक्षर

- ① भागीरथी उजाट पंचवांड
- ② कावरी सुशान्दा राठौर
- ③ ग्राम पटेल
- ④ उमाहर बिजारी
- ⑤ विनायक तिवारी
- ⑥ मनमोहन सिंह राठौर
- ⑦ अजयत यादव
- ⑧ अमिताभ कुमार
- ⑨ कुमलेश राठौर

- गा. नि. उजाट

अजाट - पांचा

रमेश कुमार

Block

प्रति,

क्षेत्रीय अधिकारी
छत्तीसगढ़ पर्यावरण संरक्षण मण्डल
बिलासपुर (छ.ग.)।

विषय:- ग्राम- कन्हाईबंद के ग्रामीणों के स्वास्थ्य समस्या के जानकारी के संबंध में।

संदर्भ:- आपके पत्र क्र. 1181/क्षेका./तक./छ.ग.प.सं.म./2025 बिलासपुर दिनांक 19.06.2025

-:00:-

उपरोक्त संदर्भित विषयान्तर्गत लेख है कि मेसर्स महावीर कोल वॉशरीज प्राइवेट लिमिटेड, ग्राम-कन्हाईबंद, तहरील-जांजगीर, जिला-जांजगीर चाम्पा (छ.ग.) के पर्यावरण प्रदूषण से संबंधित ग्राम-कन्हाईबंद के ग्रामीणों में विगत वर्ष में स्वास्थ्य संबंधी बीमारी/समस्या की जानकारी निम्नानुसार है:-

क्र.	नाम	पिता का नाम	उम्र	मो.न.	बीमारी/समस्या	कब से	वर्तमान स्थिति	रिमार्क
1	शंकर पटेल	समारू	30	9131399425	खांसी	2 दिन	स्वस्थ	
2	नरेश पटेल	समारू	38	9131399425	खांसी	3 दिन	स्वस्थ	
3	जगदीश पटेल	विष्णु पटेल	35	9131399425	एलर्जी	2 दिन	स्वस्थ	
4	जमोत्री पटेल	बलवत पटेल	34	9329762048	एलर्जी	4 दिन	स्वस्थ	
5	वेदवती बरेठ	रामायण	39	6266645533	खांसी	2 दिन	स्वस्थ	
6	सुखबाई यादव	गोरेलाल	31	9516299918	खांसी	3 दिन	स्वस्थ	
7	गोरेलाल यादव	संतराम	48	9516299918	खांसी	3 दिन	स्वस्थ	
8	तिजाऊ बरेठ	रामगोपाल	32	8818810011	एलर्जी	3 दिन	स्वस्थ	
9	राधा यादव	संतोष	38	7613737559	खांसी	2 दिन	स्वस्थ	
10	शिवशंकर यादव	कुसवा	29	7613737559	खांसी	2 दिन	स्वस्थ	
11	किशन यादव	कुसवा	32	7613737559	खांसी	4 दिन	स्वस्थ	
12	सुकवारा यादव	सुरेश	60	7067444846	खांसी	2 दिन	स्वस्थ	
13	खेवन यादव	सुरेश	39	6267694673	एलर्जी	3 दिन	स्वस्थ	
14	सुनिता यादव	खेवन	36	6267694673	खांसी	2 दिन	स्वस्थ	
15	भावना यादव	खेवन	23	6267694673	खांसी	3 दिन	स्वस्थ	
16	गजपति तिवारी	झाडूराम	57	7354244268	खांसी	2 दिन	स्वस्थ	
17	निकिता राठौर	उमेश	25	9340678944	एलर्जी	2दिन	स्वस्थ	
18	कावेरी राठौर	नरोत्तम प्रसाद	75	9340678944	खांसी	4 दिन	स्वस्थ	
19	सुनिता राठौर	उमेश	50	9340678944	खांसी	2 दिन	स्वस्थ	

अमित यादव
भिलासपुर

अंजना पंत
भिलासपुर


प्रभारी

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