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# Ecological Enumeration of Tree Vegetation and Their Contribution in Removal of Atmospheric Pollution Load: A Case Study in an Industrial Complex of Western Orissa, India

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**Abstract:** The study involves a detailed ecological and taxonomic enumeration of tree vegetation in and around the thermal power station (ITPS) at Banharpali, Jharsuguda district of Orissa. Information on phyto-sociological characters were used to calculate species frequency, density, girth size, canopy coverage and Importance Value Index (IVI), dominance and evenness indices. Presence of 37 native and 17 ornamental tree species besides planted trees were recorded. Species richness varied from 1 to 22, expected maximum diversity ($\bar{H}_{max}$) from 1.099 to 3.091, observed diversity from 0.877 to 2.708, gap in diversity from 3% to 44%, The dominance index (Cd) from 0.082 to 0.516 and evenness index (E′) from 0.7 to 0.8. The canopy density of different sites varied from 5% to 252% with a total canopy area from 1,838,472 to 2,639,010 $m^2$. From the coal combustion data, it was estimated that the ITPS annually releases 2.22 million tonnes of carbon dioxide ($CO_2$) into atmosphere and vegetation in ITPS complex was able to sequester 4.6%–6.7% of the emitted $CO_2$. Annual dust emission by ITPS power plant was estimated to be 3318 tonnes. Vegetation inside ITPS complex was able to collect only 6.13%–8.8% (203–291 tonnes/year) of the emitted dust. However, if vegetational leaf area of surrounding forest around ITPS campus is taken into consideration, total annual dust collection figure amounts to 2413 (71%) to 4711 tonnes (>100%).

**Key words**: Tree, ecological enumeration, canopy area, carbon sequestration, dust collection.

## Introduction

Vegetation refers to the sum total of different plant forms of an area. It is considered as an important and integral part of the environment. Productive, protective and regulative properties of the vegetation contribute to the stability of the environment (Murthy, 1978; Myers, 1994). There have been numerous scientific evidences on the ameliorative property of the vegetation, through which the vegetation component plays an important role in the pollution management of an area (Ravindranath, 2007; Rawat and Kishwan, 2008). Therefore, it is always imperative to conserve, manage and sustain the vegetation as a green belt around an industrial-urban complex to mitigate the intense problem of pollution. A thorough survey and quantitative analysis of plant life forms in an industrial complex is quite essential as an integral part of the environmental management programme. Keeping this concept in view, the present study was undertaken for ecological exploration of the

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vegetation in and around the ITPS, Banharpali at Jharsuguda district of Orissa.

## Experiment

### Sampling

The vegetational analysis of all the sites were made by appropriate random sampling technique (for each site, 5 random quadrates each covering 10 × 10 m area) by making frequent visit to the sites. On each of the sampling site data were recorded to enlist the existing tree species (Brahmam and Saxena, 1995; Hanes, 1961), number of trees and girth (CBH) of individual tree species, their height and canopy coverage for further quantification of their frequency, density, diversity and evenness in distribution.

### Calculation

Data collected from different sites through sampling were subjected to different analyses following calculation of Misra (1968).

$$\text{Frequency (\%)} = \frac{\text{Number of quadrats in which species occured}}{\text{Total number of quadrats}} \times 100$$

$$\text{Density} = \frac{\text{Number of individuals of a species}}{\text{Total number of quadrats}}$$

Diversity:

Observed diversity $\bar{H}_{\text{obs}} = -\sum \frac{n_i}{N} \ln \frac{n_i}{N}$

where $n_i$ = IVI of individual species
$N$ = Sum total IVI of all species.

Expected maximum diversity $\bar{H}_{\max} = ln(s)$

where '$s$' = Number of species.

Dominance: Dominance Index ($Cd$) = $\sum \left( \frac{n_i}{N} \right)^2$

Evenness index: $E' = \frac{\bar{H}_{\text{obs}}}{\bar{H}_{\max}}$

Species which exhibits maximum IVI is termed as dominant species. Basal area was calculated by measuring circumference of trees at breast height (CBH = 2πr); canopy coverage was calculated from tree crown and important value index as a sum of frequency, relative density and relative basal area. Carbon sequestration and dust collecting potential has been calculated based on certain data provided by Larcher (1995) and Ghosh (2005) respectively.

## Results and Discussion

### Plantation sites

Plantation in different sites of ITPS complex was surveyed through sampling techniques in different sites (5 random samplings per site). Age class of different plants were ascertained through girth and height analysis. The survey revealed the plantation of following species in the ITPS complex (Table 1). Planted trees in 20 high density plantation sites (site 1 to 20) and 19 green belt sites (site I to XIX) were categorized into 3 age class groups (1–3 years, 3–7 years and > 7 years old). Tables 2 and 3 present the data on different age categories of trees in different sites. In high density plantation areas maximum number of 1–3 year old saplings, 3–7 year old and more than 7 years old plant individuals are recorded from site-9. With respect to green belt area, site X presented the highest number of planted saplings. However, 3–7 year old plants were maximally recorded from site XVII. Maximum number of > 7 year old plants was recorded in site XII. With respect to total number of planted individuals, site 9 and site XII showed the highest number of planted trees among high density plantation and green belt sites respectively.

Figure 1 reveals the total number of planted trees under different age categories in high density plantation and green belt areas. The number of 1–3 year and 3–7 year old plants was more in the former than that in green belt area. However, with respect to > 7 year old category, significantly more number of plants were recorded from the green belt area. Total planted trees in both the areas were 77,623 out of which 27% belong to 1–3 year old category, 32% to 3–7 year old category and the rest 41% to > 7 year old category in the ITPS complex. Besides, number of planted species in the residential area and on road sides were estimated to be 3868 and 4329 respectively. All these plants were under more than 7 year age category of plants. Thus, the total number of planted trees in the ITPS complex was 85,820.

### Planted Ornamental Species

In addition to plantation of different tree species, seventeen ornamental species were observed to have been planted in the ITPS complex. List of such species is presented in Table 4.

### Native tree species

Table 5 presents the list of 37 native tree species recorded in ITPS complex.

**Table 1: Tree species planted at ITPS complex**

| *Sl No.* | *Name of the Species* | *Name of the family* | *Local name* |
|---|---|---|---|
| 1 | *Acacia auriculiformis* | Mimosaceae | Akashia |
| 2 | *Acacia seamea* | Mimosaceae | Akashia |
| 3 | *Albizzia lebbeck* | Caesalpiniaceae | Sirish |
| 4 | *Alstonia scholarish* | Apocynaceae | Chhatim |
| 5 | *Anthocephalus kadamba* | Rubiaceae | Kadamba |
| 6 | *Artocarpus altilis* | Moraceae | Panash |
| 7 | *Azadrachta indica* | Meliaceae | Neem |
| 8 | *Callistemon lanceolatus* | Myrtaceae | Bottle brush |
| 9 | *Caryota urens* | Palmae | Bottle palm |
| 10 | *Cassia excelsa* | Caesalpiniaceae | Chakhunda |
| 11 | *Cassia siamea* | Caesalpiniaceae | Chakunda |
| 12 | *Cassia spectabilis* | Caesalpiniaceae | Bada chakunda |
| 13 | *Casurina equisitifolia* | Casurinaceae | Jhaun |
| 14 | *Dalbergia sisoo* | Fabaceae | Sisoo |
| 15 | *Delonix regia* | Caesalpiniaceae | Golmohar |
| 16 | *Eucalyptus maculata* | Myrtaceae | Eucalyptus |
| 17 | *Gmelina arborea* | Verbenaceae | Gambhari |
| 18 | *Lagerostroemia speciosa* | Lytharaceae | Jarul |
| 19 | *Litchi chinensis* | Sapindaceae | Litchi |
| 20 | *Mangifera indica* | Anacardiaceae | Amba |
| 21 | *Mimusops elongi* | Sapotaceae | Baula |
| 22 | *Peltophorum pterocarpum* | Caesalpiniaceae | Radhachuda |
| 23 | *Polyalthia longifolia* | Anonaceae | Deodaru |
| 24 | *Pongamia pinnata* | Fabaceae | Karanja |
| 25 | *Psidium guava* | Myrtaceae | Pijuli |
| 26 | *Tectona grandis* | Verbenaceae | Saguan |

**Table 2: Number of planted tree species in different high density plantation sites**

| *Site No.* | *1–3 year old* | *3–7 year old* | *> 7 year old* | *Total* |
|---|---|---|---|---|
| 1 | 2685 | 220 | 95 | 300 |
| 2 | Nil | Nil | Nil | Nil |
| 3 | Nil | Nil | Nil | Nil |
| 4 | Nil | Nil | Nil | Nil |
| 5 | 755 | 616 | 904 | 2275 |
| 6 | 216 | 488 | 500 | 1204 |
| 7 and 8 | 391 | 171 | 143 | 705 |
| 9 | 2970 | 3085 | 2812 | 8867 |
| 10 | 504 | 808 | Buk | 1312 |
| 11 | Nil | 1078 | 1006 | 2084 |
| 12 | 774 | 423 | 286 | 1453 |
| 13 and 14 | 398 | 425 | 96 | 919 |
| 15 | 1725 | 1075 | 2413 | 5233 |
| 16 | Nil | 33 | 107 | 140 |
| 17 | 1976 | 2701 | Nil | 4677 |
| 18 | 771 | 801 | 536 | 2108 |
| 19 | 2682 | 2451 | 1014 | 6147 |
| 20 | Nil | Nil | Nil | Nil |
| **Total** | 15,847 | 14,375 | 9,912 | 40,134 |

**Table 3: Number of planted tree species in different green belt plantation sites**

| *Site No.* | *1–3 year old* | *3–7 year old* | *> 7 year old* | *Total* |
|---|---|---|---|---|
| I | 425 | 320 | 227 | 972 |
| II | Nil | 456 | Nil | 456 |
| III | 1252 | 697 | 996 | 2945 |
| IV | 199 | 158 | 343 | 700 |
| V | 681 | 428 | 348 | 1457 |
| VI | Nil | 512 | Nil | 512 |
| VII | 111 | 1358 | 1725 | 3194 |
| VIII | 119 | 988 | 92 | 1199 |
| IX | Nil | Nil | Nil | Nil |
| X | 2380 | 1043 | 1546 | 4969 |
| XI | Nil | Nil | 2550 | 2550 |
| XII | Nil | Nil | 7200 | 7200 |
| XIII | Nil | Nil | 5000 | 5000 |
| XIV | Nil | Nil | Nil | Nil |
| XV | Nil | 1567 | 234 | 1801 |
| XVI | 182 | 858 | 1459 | 2499 |
| XVII | 292 | 1629 | 114 | 2035 |
| XIX | Nil | Nil | Nil | Nil |
| **Total** | 5,641 | 10,014 | 21,834 | 37,489 |

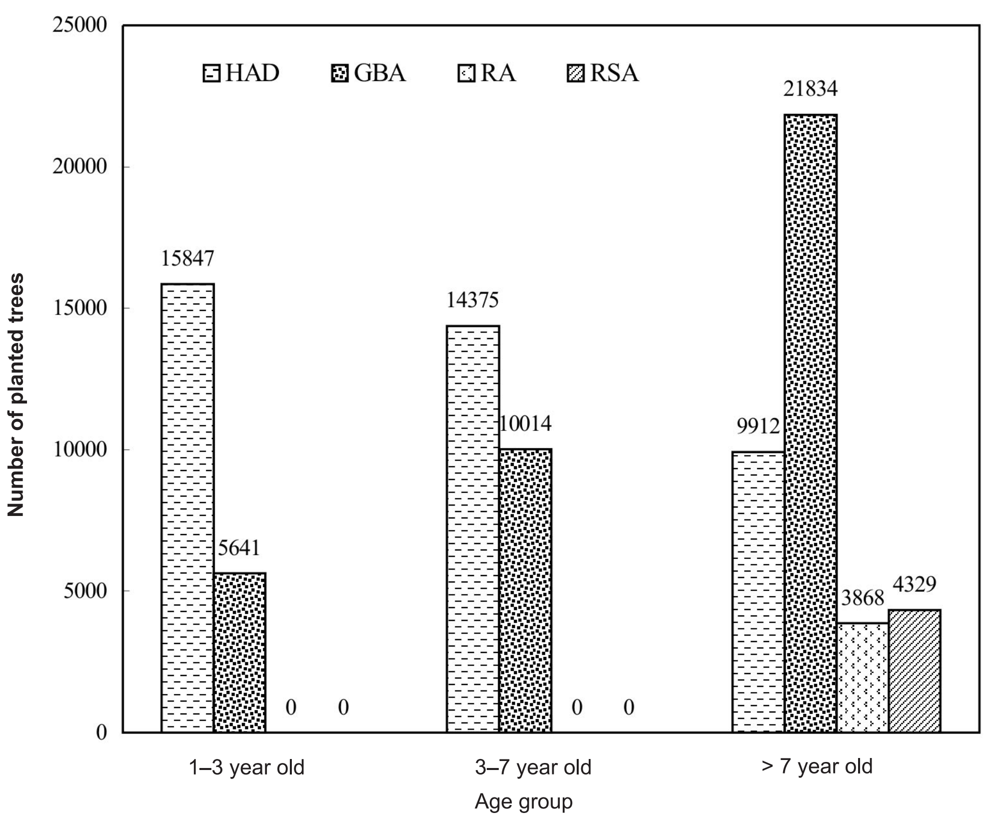


**Figure 1: Number of planted trees under different age groups from different areas of ITPS.**
(*Note:* HDA = High density area; GBA = Green belt area; RA = Residential area; RSA = Road side area)

**Table 4: List of ornamental tree species found in ITPS complex**

| Sl No. | Name of the plant species | Name of the family | Local name |
|---|---|---|---|
| 1 | *Acalypha* sp | Euphorbiaceae | |
| 2 | *Allamanda* sp | Apocyanaceae | |
| 3 | *Bougainvillea spectabilis* | Nyctaginaceae | Kagaja |
| 4 | *Calliendra hematocephala* | Caesalpiniaceae | |
| 5 | *Callistemon lanceolatus* | Myrtaceae | |
| 6 | *Chrysalidiocarpus butescens* | Palmae | Areca palm |
| 7 | *Codiaeum varigata* | Euphorbiaceae | Baxa |
| 8 | *Duranta repens* | Verbenaceae | |
| 9 | *Hibiscus rosa-sinensis* | Malvaceae | Mandara |
| 10 | *Ixora coccinia* | Rubiaceae | Rangani |
| 11 | *Juniperous chinensis* | Coniferaceae | Juniperos |
| 12 | *Livistonia rotundifolia* | Palmae | China palm |
| 13 | *Mussaendra phillipica* | Rubiaceae | Musunda |
| 14 | Nerium oleander | Apocyanaceae | Karabira |
| 15 | *Rosa hybrida* | Rosaceae | Golap |
| 16 | *Tecoma gaudichaudi* | Bignoniaceae | |
| 17 | *Thuja compacta* | Coniferaceae | Thuja |

**Total tree density, species richness, diversity, dominance and canopy coverage**

Quantification of tree density, both natural and planted were based on sampling techniques from five 10 × 10 $m^2$ area. On the basis of mean and standard error of mean of the samples the total tree density, both natural and planted are approximated as follows using the equation of normal distribution, Mean ± 1.96 SEM.

Natural tree density in high density plantation site – 186,880

Planted tree density in high density plantation site – 77,300

Natural tree density in green belt plantation site – 124,758

Planted tree density in green belt plantation site – 85,260

Thus the number of natural tree density as well as planted tree density in ITPS complex approximates to 311,638 and 162,560 respectively with a total tree density of 474,198.

Tables 6 and 7 present the species richness, diversity, dominance indices and canopy coverage in different high density plantation and green belt sites, respectively, in ITPS campus. Species richness refers to total number of species recorded from different sites. In high density plantation sites, maximum richness is exhibited by Site 19 (22 species) and in green belt sites, it was maximum in Site V (19 species). Sites having species richness value of more than 10 are considered as natural vegetation site. On this basis, 23 different sites from high density plantation and green belt area are the natural vegetation sites. Sites 1, 5, 7, 8, 13, 14, 17 and 18 from high density area and sites X, XI, XII, XIII, XIV, XV and XVI from the green belt area support species richness less than 10 thus, and their natural vegetational characteristics have been much affected. Expected maximum diversity ($\bar{H}_{max}$) in different sites varied from 1.386 (Site 1) to 3.091 (Site 19). In high density plantation area, observed diversity ($\bar{H}_{obs}$) was maximum in Site 19. Among green belt sites, site-VI showed the maximum observed diversity. Gap between the expected and observed diversity ranged from 3 (Site 11) to a maximum of 44% (in Site 17) in high density plantation area. The corresponding range of gap for green belt sites is 8 (Site IX) to 27% (Site II). The number of sites showing more than 15% gap were 9 in green belt area and 7 in high density plantation area. Appropriate protection measures and plantation strategies are recommended in these sites to fill up the gap in existing vegetational diversity. Dominance indices in different sites ranged from 0.082 to 0.516. Evenness index analysis, however, exhibited a value more than 0.5 in all the sites which indicated usual even distribution of plant species in the area.

Canopy density (as revealed from the data of canopy area/100 $m^2$) was maximum in Site 16 (187.85 $m^2$) of high density plantation area. The corresponding value for green belt area was noted in site-VIII (251.718 $m^2$). Site XIV (from green belt area) and Site 17 from high density plantation area showed the minimal canopy density. Sites with canopy density less than 70% are classified as poor canopied sites. Sites 1, 4, 5, 6, 7, 8, 10, 12, 15, 17, 18 and 20 from high density area and Sites I,

**Table 5: List of native species found in the ITPS complex**

| Sl No. | Name of the Species | Name of the family | Local name |
|---|---|---|---|
| 1 | *Albizzia lebbek* | Caesalpinaceae | Sirish |
| 2 | *Anogeissus latifolia* | Combretaceae | Dhaura |
| 3 | *Bombax malbaricum* | Malvaceae | Simuli |
| 4 | *Bridelia retusa* | Euphorbiaceae | Khais |
| 5 | *Buchanania lanzan* | Anacardiaceae | Chara |
| 6 | *Butea monosperma* | Papilionaceae | Palasha |
| 7 | *Careya arborea* | Lecythidaceae | Kumbhi |
| 8 | *Cassia fistula* | Caesalpinaceae | Sunari |
| 9 | *Chloroxylon swietenia* | Meliaceae | Bheru |
| 10 | *Cleistanthus collinus* | Euphorbiaceae | Karla |
| 11 | *Diospyros melanoxylon* | Ebenaceae | Kendu |
| 12 | *Emblica officinalis* | Euphorbiaceae | Anla |
| 13 | *Eugenia jambolina* | Myrtaceae | Jamun |
| 14 | *Ficus bengalensis* | Moraceae | Bara |
| 15 | *Ficus glomerate* | Moraceae | Dimri |
| 16 | *Ficus religiosa* | Moraceae | Aswastha |
| 17 | *Gardenia gummifera* | Rubiaceae | Dum Kurudu |
| 18 | *Gardenia latifolia* | Rubiaceae | Kurudu |
| 19 | *Holarrhena antidysenterica* | Apocynaceae | Kurei |
| 20 | *Ixora parviflora* | Rubiaceae | Telkuruma |
| 21 | *Lagerstroemia parviflora* | Lythraceae | Senha |
| 22 | *Lannea coromandolica* | Anacardiaceae | Moi |
| 23 | *Madhuca indica* | Sapotaceae | Mahula |
| 24 | *Mangifera indica* | Anacardiaceae | Amba |
| 25 | *Melia azadrachta* | Meliaceae | Mahanimba |
| 26 | *Morinda tinctoria* | Rubiaceae | Achhu |
| 27 | *Scleichera oleosa* | Sapindaceae | Kusum |
| 28 | *Semecarpus anacardium* | Anacardiaceae | Bhalia |
| 29 | *Shorea robusta* | Dipterocarpaceae | Sal |
| 30 | *Tamarindus indica* | Caesalpinaceae | Tentuli |
| 31 | *Tterminalia arjuna* | Combretaceae | Arjuna |
| 32 | *Terminalia belerica* | Combretaceae | Bahada |
| 33 | *Terminalia chebula* | Combretaceae | Harida |
| 34 | *Terminalia tomentosa* | Combretaceae | Sahaja |
| 35 | *Woodfordia fruticosa* | Lythraceae | Dhatki |
| 36 | *Zizyphus jujuba* | Rhamnaceae | Borkuli |
| 37 | *Zizyphus xylopyra* | Rhamnaceae | Ghanta |

VIII, IX, XII, XIV and XVII from green belt area were thus catagorized as poor canopied sites.

However, with respect to total canopy area, Site 9 (from high density plantation area) and Site II (from green belt area) showed maximum total canopy coverage. Total canopy area in green belt area amounted to 854,878 $m^2$ and the value for the high density plantation area was 874,220 $m^2$.

In addition, random sampling of ITPS residential area revealed the presence of 3868 plants generally fruit bearing and shade providing species. On average an individual tree of this category maintains a canopy diameter of 4.5 metre having the projected canopy cover of 15.91 $m^2$. Thus, the residential area plant cover contributes to total canopy coverage of 61,540 $m^2$. Apart from this, total number of plants on road sides of ITPS campus is estimated to be 4329, each having an average canopy diameter of 3.75 metre. The total canopy coverage from road side plants is thus calculated to be 478,34 $m^2$. Canopy cover contributed by different areas of the ITPS complex is illustrated in Figure 2. Total canopy cover of ITPS complex is estimated to be 1,838,472 $m^2$.

**Table 6: Species richness, diversity, dominance and canopy coverage in high density plantation sites**

| *Site No.* | *Area (ha)* | *Species richness* | $\bar{H}_{max}$ | $\bar{H}_{obs}$ | *Gap in diversity (%)* | *Dominance index (Cd)* | *Canopy area/100 m²* | *Total canopy area (m²)* |
|---|---|---|---|---|---|---|---|---|
| 1 | 2.0 | 04 | 1.386 | 0.908 | 34 | 0.516 | 10 | 2036 |
| 2 | 15.0 | 16 | 2.773 | 2.633 | 05 | 0.082 | 122 | 182807 |
| 3 | 3.5 | 16 | 2.773 | 2.348 | 15 | 0.127 | 137 | 48031 |
| 4 | 4.0 | 14 | 2.639 | 2.329 | 12 | 0.119 | 35 | 14412 |
| 5 | 3.5 | 07 | 1.946 | 1.616 | 17 | 0.231 | 35 | 12252 |
| 6 | 2.0 | 13 | 2.565 | 2.031 | 21 | 0.155 | 35 | 7044 |
| 7 | 1.0 | 09 | 2.197 | 1.891 | 14 | 0.192 | 36 | 3596 |
| 8 | 1.0 | 09 | 2.197 | 1.891 | 14 | 0.192 | 36 | 5395 |
| 9 | 22.0 | 14 | 2.639 | 2.385 | 10 | 0.114 | 158 | 346962 |
| 10 | 2.5 | 13 | 2.565 | 2.298 | 11 | 0.123 | 60 | 15047 |
| 11 | 5.5 | 10 | 2.302 | 2.239 | 03 | 0.112 | 88 | 48486 |
| 12 | 5.0 | 18 | 2.890 | 2.515 | 13 | 0.119 | 30 | 14945 |
| 13 | 2.0 | 06 | 1.792 | 1.641 | 09 | 0.228 | 86 | 17192 |
| 14 | 1.0 | 06 | 1.792 | 1.641 | 09 | 0.228 | 86 | 8596 |
| 15 | 12.0 | 10 | 2.303 | 1.759 | 24 | 0.269 | 24 | 29240 |
| 16 | 2.5 | 17 | 2.833 | 2.078 | 27 | 0.163 | 188 | 46960 |
| 17 | 2.5 | 04 | 1.386 | 0.917 | 44 | 0.515 | 05 | 126 |
| 18 | 1.5 | 04 | 1.386 | 1.275 | 08 | 0.515 | 11 | 1656 |
| 19 | 8.0 | 22 | 3.091 | 2.708 | 13 | 0.093 | 71 | 56462 |
| 20 | 3.0 | 14 | 2.639 | 2.336 | 11 | 0.123 | 43 | 12976 |

Species richness = Number of species; $\bar{H}_{max}$ = Expected diversity $\bar{H}_{obs}$ = Observed diversity.

**Table 7: Species richness, diversity, dominance and canopy coverage in green belt sites**

| *Site No.* | *Area (ha)* | *Species richness* | $\bar{H}_{max}$ | $\bar{H}_{obs}$ | *Gap in diversity (%)* | *Dominance index (Cd)* | *Canopy area/100 m²* | *Total canopy area (m²)* |
|---|---|---|---|---|---|---|---|---|
| I | 15.0 | 13 | 2.564 | 2.258 | 12 | 0.147 | 65 | 97056 |
| II | 10.0 | 18 | 2.890 | 2.098 | 27 | 0.223 | 143 | 143020 |
| III | 4.5 | 10 | 2.302 | 1.866 | 19 | 0.198 | 78 | 35298 |
| IV | 3.5 | 18 | 2.890 | 2.384 | 18 | 0.159 | 97 | 34078 |
| V | 4.0 | 19 | 2.944 | 2.285 | 22 | 0.185 | 139 | 55750 |
| VI | 5.0 | 16 | 2.773 | 2.444 | 12 | 0.115 | 73 | 36720 |
| VII | 2.5 | 14 | 2.639 | 2.216 | 16 | 0.154 | 252 | 62930 |
| VIII | 4.5 | 08 | 2.079 | 1.814 | 13 | 0.195 | 27 | 11995 |
| IX | 3.0 | 14 | 2.639 | 2.434 | 08 | 0.106 | 26 | 7701 |
| X | 4.0 | 09 | 2.197 | 1.646 | 25 | 0.297 | 194 | 77660 |
| XI | 1.5 | 01 | — | — | — | — | 89 | 13275 |
| XII | 6.0 | 01 | — | — | — | — | 28 | 16662 |
| XIII | 2.5 | 01 | — | — | — | — | 104 | 26033 |
| XIV | 1.25 | 10 | 2.303 | 2.009 | 13 | 0.155 | 12 | 1468 |
| XV | 2.0 | 03 | 1.099 | 0.877 | 20 | 0.452 | 96 | 19115 |
| XVI | 5.0 | 07 | 1.945 | 1.657 | 15 | 0.238 | 210 | 104945 |
| XVII | 5.5 | 14 | 2.639 | 2.268 | 14 | 0.129 | 41 | 22761 |
| XIX | 7.25 | 11 | 2.398 | 1.953 | 19 | 0.225 | 122 | 88408 |

Species richness = Number of species, $\bar{H}_{max}$ = Expected diversity $\bar{H}_{obs}$ = Observed diversity.

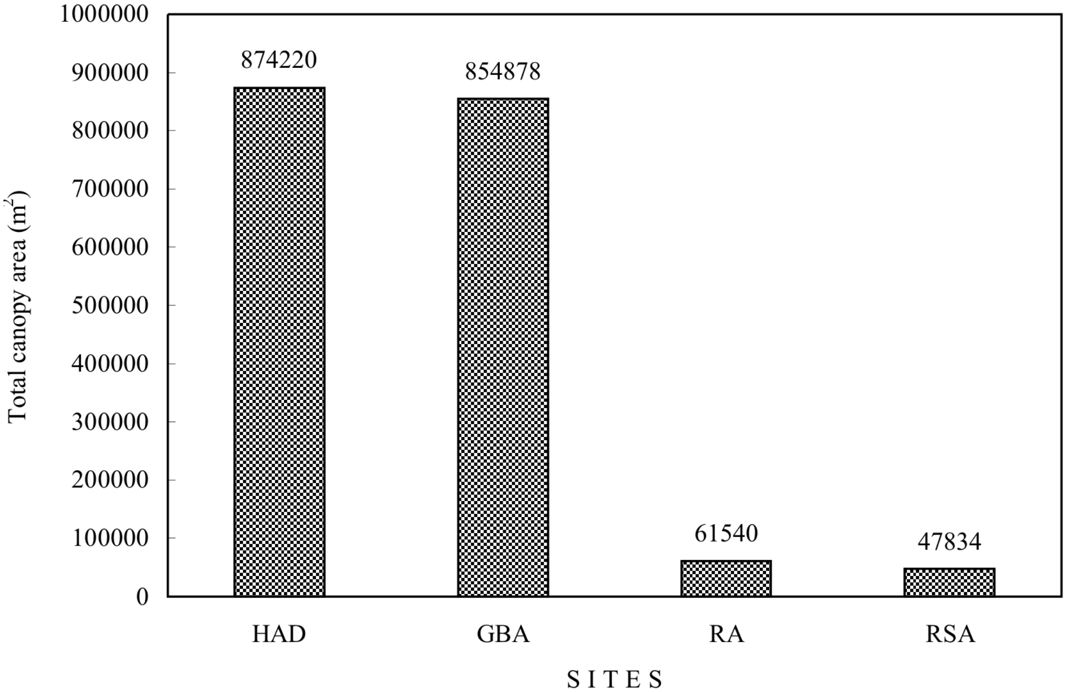


**Figure 2: Total canopy area of different sites at ITPS complex.**
(*Note:* HDA = High density area; GBA = Green belt area; RA = Residential area; RSA = Road side area)

**Role of tree vegetation of ITPS complex in carbon sequestration**

Green vegetation acts as a sink by utilizing atmospheric $CO_2$ through the process of photosynthesis. During the process, energy is harvested from solar radiation and the process exclusively occurs in specialized organelle called chloroplast of green leaves, where $CO_2$ gets reduced to glucose. Hence green leaves when exposed to sun can uptake $CO_2$ from atmosphere and therefore can act as natural sink. It has been reported that sun leaves of tropical woody species can up take $CO_2$ at the rate of 10–15 micromole per $m^2$ per second (Larcher, 1995). On this basis, quantum of $CO_2$ uptake by the green vegetation of ITPS complex was approximated as follows.

The total canopy coverage of the complex was estimated to vary from 1838472 to 2639010 $m^2$. Assuming a general 40% canopy overlap, expected canopy coverage exposed to sun was calculated to be 1,103,083–1,583,406 $m^2$. A square metre of canopy area supports green leaf area of around 10 $m^2$. This estimated green leaf surface is exposed to solar radiation minimally for a period of 10 hours a day. A square metre of green leaves exposed to sunlight can uptake 10–15 micromole of $CO_2$ or 12.5 micromole of $CO_2$ on average per second. This amounted to a total uptake of $4.5 \times 10^5$ micromole $CO_2$ per day or 19.8 g $CO_2$ per sunlight exposed green leaves per day. Since the ITPS complex has 11,030,830–15,834,060 $m^2$ of sun exposed to leaves, the total $CO_2$ uptake by the green vegetation in a day amounted to 218.41–313.5 tonnes per day or 79,720–1,14,430 tonnes per annum. This is a conservative estimate as green woody vegetation as well as only sunlight-exposed to leaves have been taken into account. However, the actual sequestration may be another 25–30% more (total 103,636-148,760 tonnes/annum) if shade leaves are considered as they have also the capability to accept carbon for photo-assimilation with lower rate.

Coal combustion data of ITPS (average of 5 years from 2000–05) indicates an average utilization of 2486. $2 \times 10^3$ metric tonnes per annum. Percentage of fixed carbon of the consumed coal being 24.36%, the annual coal combustion results in the release of 2.22 million tonnes of $CO_2$ per year. Thus, the $CO_2$ sequestration by green tree vegetation present in ITPS complex is limited to only 4.6%–6.7% of the total $CO_2$ emission by ITPS.

However, if forest area that surrounds ITPS complex is taken into consideration, the picture emerges to be different. ITPS complex was found to be surrounded by regenerating/scrub forest patches. Such forest extends around 4 to 5 km radius beyond the boundary of ITPS complex. Area of such forest is approximated to be 5000 to 7000 ha and vegetationally supports most of the native species that are recorded from ITPS campus. Canopy of such forest is discontinuous and thin in nature and canopy density varied from 30–35 $m^2/100\ m^2$. Such forest of 5000 ha with 30% canopy density bears a total canopy area of $15 \times 10^6\ m^2$ and this figure corresponds to $9 \times 10^6\ m^2$ of sunlight exposed canopy area of $9 \times 10^7\ m^2$ of green leaf area. Considering 19.8 g $CO_2$ uptake per $m^2$ of green leaf area per day, carbon dioxide sequestration by such canopy area amounts to 1782 tonnes per day or 650,430 tonnes per annum. The sequestration by shade leaves can improve this figure of $CO_2$ sequestration to 30% more. Thus, the final amount of annual $CO_2$ sequestration by surrounding forest area of ITPS finally amounts to 845,559 tonnes/year and total $CO_2$ sequestration figures by forest patch and plantation patch comes to 994,320 tonnes/year.

The total $CO_2$ sequestration by green vegetation of ITPS and surrounding forest accounts for 44.80% of the total emission by ITPS. It may be noted here that the surrounding forest having only 30% canopy density can account for 38% of total $CO_2$ emitted from the power plant of ITPS. The study suggests the role of surrounding forest in mitigating the impact of $CO_2$ emitted by ITPS.

**Dust collecting capacity of the tree vegetation of ITPS complex**

Importance of the plant to reduce the dust in the environment has been emphasized by several workers (Das and Pattanaik, 1978; Maiti, 1993; Ghosh, 2005). Ghosh (2005) reviewed the dust collecting capability of some Indian tree species and reported that their dust collecting capability varies with species. The rate of dust emission from ITPS power plant is calculated as per the following estimates:

(i) Number of flues = 2
(ii) Quantum dust emitted per flue = 150 $mg/m^3$
(iii) Velocity of gas = 22 m/second
(iv) Gas per hour = $12.6 \times 10^5\ m^3$
(v) Dust from each flue = $12.6 \times 10^5 \times 150$ mg/hr
(vi) Dust from 2 flues = $12.6 \times 10^5 \times 150 \times 2$ mg/hr = 278 kg/hr
(vii) Total dust emission in 2 flues = $378 \times 24 \times 365$ = 3311.28 tonnes/yr

Tropical plant species show a dust collecting range of 2–5.35 $g/m^2$ of leaf surface (with an average value of 3.68 $g/m^2$). Assuming the total green leaf area estimate of ITPS complex to be the dust collecting surface (18,384,720–26,390,100 $m^2$), dust collecting capacity of the entire vegetation of ITPS complex was calculated to be 67.65–97.11 tonnes. Assuming that the turn over rate of dust collection by leaves is 2–4 times (average three) a year because of weather parameters, the actual dust collection may vary from 203–291 tonnes per annum in the complex. Thus, the dust collection capacity of the vegetation in ITPS complex accounts only 6.13% to 8.8%. However, if collecting surface area of surrounding forest is taken into consideration, the dust collection figure improves to an additional 2413 to 4711 tonnes per annum ($15 \times 10^6\ m^2$ of leaf area from surrounding forest). Thus, total dust collection amounts to 2345 to 4691 tonnes per annum and this collection mostly matches with the dust emitted from the ITPS plant. The study further highlights the role of surrounding forest in mitigating the problem of dust pollution due to power plant. Therefore, it is highly recommended that ITPS authority on priority basis should take all measures for protection and expansion of surrounding forest of the area.

The increased awareness on climate change and concerns regarding green house gas emissions have resulted in the ratification of the Kyoto Protocol by several developed and developing countries. Carbon sequestering through afforestation and reforestation activities and then carbon credits generated from such projects under the Clean Development Mechanism (CDM) is one possible option to countries to mitigate the impact of climate change. Extensive studies have been made in different parts of the world on the impact of climate change and the role of forests in mitigation and adaptation strategies, while providing sustainable livelihood to forest communities (Chaturvedi et al., 2007; Ravindranath et al., 2008). The present work is a humble attempt to quantify the carbon sequestration and dust collection potential of a forest and plantation patch in order to sensitize the people for the protection and conservation of forest.

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