RESEARCH ARTICLE

Carbon Sequestration Studies at Nagpur Municipal Corporation's Water Treatment Plant at Pench I & II by Existing Greenbelt

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ABSTRACT

Carbon sequestration describes long-term storage of carbon dioxide or other forms of carbon to either mitigate or defer global warming and avoid dangerous climate change. Present study deals with the absorption of the atmospheric carbon in the study area selected by selecting planting methods that return biomass to the soil and enhance the conditions in which the carbon within the plants will be reduced to its elemental nature and stored in a stable state through Green belts. It is calculated that, Carbon Absorption by Green Belt Carbon absorption rate is approximated 49.27 kg per mature plant per year as per international standards. As per CPCB (2000) Guidelines, the trees to be planted are 1250 plants per acre, 1250 trees will absorb 1250 X 49.27 = 61587.50 kg of carbon per year per Acer. Project Site (Pench I & II - 1.16 acre) has sequestered 18724 kg of carbon per Acre.

Keywords: Carbon sequestration, Pench project, Nagpur Municipal Corporation.
INTRODUCTION

Climate change has become a global issue. Almost all countries have paid attention towards alarming environmental concerns. Green plants act as a natural sink for carbon, which is one of the greenhouse gases. Carbon dioxide is naturally captured from the atmosphere through biological, chemical, or physical processes. Bio-sequestration or carbon sequestration through biological processes affects the global carbon cycle. The process of removal of carbon from the atmosphere and storing it in tree's parts is known as carbon sequestration. Kanth et al (1960) has given good account on green belt plant species selection for wind erosion, wind breaks and shelter – belts and Hu et al. (2016) mentioned the root rather than leaf litter input drives soil carbon sequestration after afforestation on a marginal cropland in his article. This is done by selecting planting methods that return biomass to the soil and enhance the conditions in which the carbon within the plants will be reduced to its elemental nature and stored in a stable state through Green belts. Greenbelt sequestration practices may have positive effects on soil, air, and water quality, be beneficial to fauna. On degraded lands, an increase of 1 ton of soil carbon pool may increase crop yield by 20 to 40 kilograms per hectare of grasses, 10 to 20 kg/ ha. Biological carbon sequestration involves removal of carbon from atmosphere by using plants and its storage in plants in the form of biomass.

Carbon sequestration is the process involved in carbon capture and the long-term storage of atmospheric Carbon Dioxide (CO₂). Carbon sequestration describes long-term storage of carbon dioxide or other forms of carbon to either mitigate or defer global warming and avoid dangerous climate change. Chavan & Rasal (2012) has well explained the carbon sequestration potential and status of Peltophorum pterocarpm (DC.) K. Heyne in his research article. Carbon dioxide is naturally captured from the atmosphere through biological, chemical, or physical processes. Jha K K (2015) has studied the carbon sequestration rate in Teak plantation in tropical moist deciduous forest in India. Artificial processes have been devised to produce similar effects, including large-scale, artificial capture and sequestration of industrially produced CO₂ using carbon sinks. Bio-sequestration or carbon sequestration through biological processes affects the global carbon cycle.

STUDY AREA

Project Pench I & II at Nagpur Municipal Corporation's Water Treatment Plant, is located at Nagpur Maharashtra (Figure 1). Nagpur has tropical savannah climate (Köppen climate classification) with dry conditions prevailing for most of the year. It receives about 163 mm of rainfall in June. The amount of rainfall is increased in July to 294 mm. Gradual decrease of rainfall has been observed from July to August (278 mm) and September (160 mm). The highest recorded daily rainfall was 304 mm on 14 July 1994. Summers are extremely hot, lasting from March to June, with May being the hottest month. Winter lasts from November to January, during which temperatures drop below 10 °C (50 °F). The highest recorded temperature in the city was 48 °C on May 19, 2015, while the lowest was 3.9 °C.

Pench Project: Phase-I

In this scheme 113.5 MLD water is drawn from Pench right bank canal by gravity to the Mahadulla pumping station. The raw water is pumped to the B.P.T. of capacity 5.7 lakhs liters through 1606 mm dia M.S. Rising Main of length 5624 m. from B.P.T. water is taken to the Gorewada balancing tank through 700 mm dia duplicate C.I. gravity main. The treated water is conveyed to Gorewada Tank through 1200 mm dia M.S. Rising Main of length 5624 m. from Gorewada Tank it is drawn to the conventional treatment plant of capacity 113.5 MLD through 1200 mm dia M.S. Rising Main of length 4000 m. The filtered and chlorinated water from the treatment plant is pumped to Seminary Hills G.S.R. of capacity 20.43 ML and Gittikhadan G.S.R. of capacity 5.94 ML. Sitabuldi G.S.R. is fed from Seminary Hills G.S.R. through 700 mm dia M.S. Feeder Main of length 4000 m.

Pench Project: Phase-II

Under Pench Phase - II a baby canal from Pench right bank canal to Mahadulla pumping station was constructed to draw additional 136 MLD of water. The raw water is pumped to the existing B.P.T. of capacity 5.70 lakh ltrs. through 1626 mm dia M.S. Rising Main of length 5.60 km from B.P.T. water is conveyed to Gorewada tank through
1500 mm dia P.S.C. 8 Kg.cm² gravity main of length 400 m. from Gorewada Tank water is taken to conventional water treatment plant of capacity 145 MLD through 1100 mm and 1000 mm dia P.S.C. 4 Kg/Sq.cm. gravity mains of length 650 m and 325 m respectively. Pure water is pumped to Seminary Hills G.S.R. of capacity 20.43 ML through 1321mm dia M.S. Rising Main of length 3760 m. In this scheme two E.S.R.s at Jaripatka and Sharda Rolling Mill each of capacity 22.7 lakhs liters are constructed.

**METHODOLOGY**

Taxonomical observations and identification of plant species is done with the help of standard, regional and online florals and resources viz. Almeida, (1996-2003); Bahadur (1993); Bhogaonkar & Devarkar, (1999); Flowers of India (2013), Hooker J. D. (1872-1897) and Singh & Karthikeyan, (2000). Estimation of carbon sequestration was done by using tree inventory data. Ravindranath & Ostwald (2008) method was used for calculating total carbon sequestered by all trees. This method was used as it is a non-destructive and is designed for tropical plant species. The estimation is done by using two parameters i.e. Height and Girth of a tree. Carbon sequestration calculation was done using following steps-

**Measurement of Height And Girth:** Height and girth of each tree species is measured during tree inventory at Pench I & II project, Nagpur.

**Calculation of Above Ground Biomass:** This calculation is done by using data of height and girth of each species. In this step above ground biomass is determined by calculating volume of a tree and multiplying it by its wood density. (Wood density of a tree is specific for each species).

**Calculation of Below Ground Biomass:** Below ground biomass is nothing but the mass of a root system of any tree. It is assumed that for any tropical tree, the below ground biomass is 26% of its above ground biomass. Hence it is calculated by using the above ground biomass values.

**Calculation of Total Dry Biomass:** Total dry biomass is calculated by adding values of above and below ground biomasses.

**Carbon Footprint and Carbon Count:**

Carbon count and trees required are calculated by consumption of CO₂ on the basis of,

1. Electricity consumption
2. Office vehicles
3. Tanker (diesel)
4. Vehicles (petrol)

3. Tanker (diesel)
4. Vehicles (petrol)

- One mature tree absorbs 49.27 kg CO₂/year. Therefore, No. of trees required to absorb the CO₂ released by electricity used is, 9520875/49.27 = 1, 93, 238.78 trees

**PENCH-I**

Consumption in average = 976500 KWH/year.
1 KWH of electricity production releases 975 gm. of CO₂ Therefore, 976500 X 975 = 952087500 gm. of CO₂/year i.e. 9520875 kg. CO₂/year
One mature tree absorbs 49.27 kg CO₂/year.

**PENCH-II**

Consumption in average = 1037990 KWH/year.
1 KWH of electricity production releases 975 gm. of CO₂ Therefore, 1037990 X 975 = 1012040250 gm. of CO₂/year i.e. 1012040 kg. CO₂/year
One mature tree absorbs 49.27 kg CO₂/year

- Calculations for carbon count CO₂ Released by Electricity Consumption
- Combustion formulae:

\[
\begin{align*}
\text{Petrol:} & \quad 2C_8H_{18} + 25O_2 & \rightarrow & \quad 16CO_2 + 18H_2O + 2631 \text{ cal.} \ (0.7197 \text{ KG/L}) \\
\text{Diesel:} & \quad 4C_8H_{23} + 71O_2 & \rightarrow & \quad 48CO_2 + 46H_2O + \text{ energy} \ (0.832 \text{ KG/L}) \\
\text{LPG:} & \quad C_3H_8 + 5O_2 & \rightarrow & \quad 3CO_2 + 4H_2O + 53 \text{ cal.} \ (0.52 \text{ KG/L})
\end{align*}
\]

- Calculation of Carbon Sequestered: For any tree total carbon sequestered till date is 50% of its total dry biomass. Hence carbon sequestration for individual tree species is calculated using total dry biomass value. Liski et. al. (2014) has produced as model to study indirect emission of forest bio-energy, other relevant information about trees in the campus of Pench I & II project like Tree trunk girth, tree height, tree age, living status, canopy organization, leaf area covered, etc. along with the following information is also collected during the field survey and incorporated in the field data diary.

- Secondary data analysis for of plants listed in the proposed Greenbelt area for its biodiversity status as per IUCN (International union for conservation of nature) for each species.

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2. Quantitative listing of herbs, shrubs and trees in the proposed area of the greenbelt and the area not under construction for Veolia plant.
3. Diversity, Density, and Frequency of the species observed in the proposed greenbelt area.
4. Medicinal and Economic importance of plant species present in the proposed greenbelt area.
5. Carbon sequestration studies and values by each tree.

**OBSERVATIONS & RESULTS**

**Vegetation Study and Tree Inventory**

As per the CPCB guidelines (2000) the plant are falls under Western Plateau and hills in South zone, where average rainfall is about 1040 mm, climate is semi-arid to dry sub humid, soil is medium to shallow black. Forest observations and structure is mentioned by Bahadur (1993). Environmental impact studies are also important to define the stress on the ecology of the particular area (Devarkar et al, 2018; Joshi et al, 2019).

There are about 2048 plant species growing in the Pench I & II project plant areas. As per the site and plant layout, scientific Greenbelt is not developed on any of the sites. But natural vegetation and Office and around areas planted with some garden varieties for aesthetication of the area. Most of the area is dominated by grasses and weeds. Along with them, Sesbania sesban there are few other species were also noted such as Tectona grandis (Teak, Sagwan), Dalbergia sissoo (Shisham), Azadirachta indica (KaduNimb), Bauhinia racemosa (Kanchan), Lantana camara (Ghaneri), Zizyphus jujuba (Bor), Cassia fistula (Bahava), Cryptostegia grandiflora (Sarpvel), Albizzia lebbeck (Shirish), Pithecellobium dulce (Vilayati Chinch), Mangifera indica (Aumbha), Tinospora cordifolia (Gulvel), Calotropis procera (Ruchaki) and grasses. The plantation is purposely watered on most of the non-construction areas of the sites. But road side plantation and garden, lawn is found well-watered.

As per taxonomic classification Pench I & II has total 59 species of 58 genera belongs to 30 families, were observed on project site. As per IUCN reports and publications only one species falls under Vulnerable category ie Santalum album from Santalaceae family. Other species those have mention as Least Concern or Data Deficient are Asteracantha longifolia (Acanthaceae), Alternanthera sessilis (Amaranthaceae), Mangifera indica (Anacardiaceae), Rhynchosia minima (Fabaceae), Pongamia pinnata (Fabaceae), Ficus carica (Moraceae), Typha latifolia (Typhaceae) and Potamogeton natans (Potamogetonaceae) have mention in the Red Data Book / Red List.

Existing green cover and open space assessment studies revealed that Pench I & II project sites have good species diversity with dominance of Gramineaceaeous species. Top 15 species are Andropogon pumilus, Setaria intermedia, Peristrophe hicalyculata, Cydonon dactylon, Alternanthera sessilis, Achyranthus aspera, Asteracantha longifolia, Hyptis suaveolens, Mucuna pruriens, Tephrosia purpurea, Euphorbia geniculata, Rhynchosia minima and Duranta repens.

**Carbon Sequestration Through Existing Greenbelt**

Carbon sequestered by existing Greenbelt was calculated by using Ravindranath and Ostwald (2008) method. During site visit it was observed that, there are many species of trees. For these species, standard average of wood density was used to determine above ground biomass. It was noted that trees in existing Greenbelt dominance of grasses, weeds and other trees are of dissimilar age group. It shows good mix of old and new plant species. Hence total dry biomass of these plant species is relatively good. Hence total carbon sequestered by existing Greenbelt is 18724 kg. (Refer Table 1 & Table 2 for details). The species in the existing green cover are the verge of maturity or matured and hence the carbon sequestration for future years will be change negligibly.

Carbon Absorption by Green Belt Carbon absorption rate is approximated 49.27 kg per mature plant per year as per international standards. As per CPCB Guidelines, the trees to be planted are 1250 plants per acre, 1250 trees will absorb 1250 X 49.27 = 61587.50 kg of carbon per year per Acer. Project Site (Pench I&II - 1.16 acre) has this much of land as greenbelt. Pench I & II (1.16 acre Greenbelt) No. of trees 1444. Therefore, by planting 1444 trees the carbon absorption will be 61587.50 x 1.16 Acre= 71441.5 kg carbon is get absorbed per year.

Present carbon emission in the plant area is very negligible during the process of water treatment for drinking purpose in the municipal corporation area of Nagpur city. But the overall projects (utilities) consuming large amount of electricity (Pench-I = 976500 Kwh/Year, Pench-II =1037990 Kwh/Year) which releases CO2 in the process of Electricity generation process. Thus, it’s a joint responsibility of electricity Production Company and User Company to increase the carbon absorption by adapting greenbelt development in the vicinity of 2000 mtrs. Veolia, Nagpur covers approximate area of 28 acres. Observations and Identification of plant species was done by experts in the field of botany especially plant taxonomy. Total numbers of trees enumerated at all sites are about 8878 that makes 10.7 acres of area under green.
CONCLUSION

Carbon sequestration rate is approximated 49.27 kg per mature plant per year as per international standards. As per CPCB (2000) Guidelines, the trees to be planted are 1250 plants per acre, 1250 trees will absorb 1250 X 49.27 = 61587.50 kg of carbon per year per Acre. Project Site (Pench I&II) has this 1.16 acre of land as greenbelt. It means, Pench I & II: (1.16 acre Green Belt) No. of trees 2048. But as all the plants are not fully grown carbon absorption is calculated as 18724 kg carbon is get absorbed per year (Table I & 2).

Present carbon emission in the plant area is very negligible during the process of water treatment for drinking purpose in the municipal corporation area of Nagpur city. But the overall projects (utilities) consuming large amount of electricity (Pench-I = 976500 Kwh/Year, Pench-II = 1037990 Kwh/Year, which releases CO2 in the process of Electricity generation process. Thus, it’s a joint responsibility of electricity Production Company and User Company to increase the carbon absorption by adapting greenbelt development in the vicinity of 2000 mtrs. Veolia, Nagpur covers approximate area of 28 acres. Observations and Identification of plant species was done by experts in the field of botany especially plant taxonomy. Total numbers of trees enumerated at all sites are about 2048 that makes 1.16 acres of area under green.

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Table 1: Carbon sequestration in the study area

| Sr. No. | Botanical Name   | Family         | Plant Count | Carbon Sequestration/Year In Kg | Total Carbon Sequestration/Year In Kg |
|---------|------------------|----------------|-------------|---------------------------------|--------------------------------------|
| 1       | Hyptis suaveolens | Acanthaceae    | 60          | 1.7                             | 102                                  |
| 2       | Ruellia tuberosa  | Acanthaceae    | 23          | 1.8                             | 41.4                                 |
| 3       | Asterotheca longiflora | Acanthaceae | 41          | 1.3                             | 53.3                                 |
| 4       | Peristrophe bicolorata | Acanthaceae | 54          | 1.2                             | 64.8                                 |
| 5       | Achyranthes aspera | Amaranthaceae  | 75          | 1.2                             | 90                                   |
| 6       | Alternanthera sessilis | Amaranthaceae | 80          | 1.1                             | 88                                   |
| 7       | Mangifera indica  | Anacardiaceae  | 2           | 80.48                           | 160.96                               |
| 8       | Anona squamosa    | Annonaceae     | 5           | 36.11                           | 180.55                               |
| 9       | Anona reticulata  | Annonaceae     | 2           | 36.22                           | 72.44                                |
| 10      | Thevetia peruviana | Apocynaceae    | 11          | 17.55                           | 193.05                               |
| 11      | Barleria cordata  | Apocynaceae    | 35          | 5.2                             | 182                                  |
| 12      | Phoritis sylvestris | Arecaceae      | 4           | 32.25                           | 129                                  |
| 13      | Borassus flabellifer | Arecaceae      | 10          | 33.54                           | 335.4                                |
| 14      | Pergularia daemia  | Asclepiadaceae | 10          | 3.2                             | 32                                   |
| 15      | Spathodea campanulata | Bignoniaceae | 4           | 84.65                           | 338.6                                |
| 16      | Tamarindus indica  | Caesalpinaceae | 10          | 60.15                           | 601.5                                |
| 17      | Bauhinia racemosa  | Caesalpinaceae | 4           | 72.4                            | 289.6                                |
| 18      | Terminalia catappa  | Combretaceae   | 8           | 87.65                           | 701.2                                |
| 19      | Ipomea hederifolia  | Convolvulaceae | 25          | 1.92                            | 33                                   |
| 20      | Cecropia indica   | Cucurbitaceae  | 23          | 2.36                            | 54.28                                |
| 21      | Bryophyllum daigremontiae | Cucurbitaceae | 24          | 3.45                            | 82.8                                 |
| 22      | Thuya arborea     | Cupressaceae   | 30          | 30.14                           | 904.2                                |
| 23      | Physalis erubescens | Euphorbiaceae  | 4           | 38.69                           | 154.76                               |
| 24      | Tephrosia purpurea  | Fabaceae       | 40          | 2.36                            | 94.4                                 |
| 25      | Butia monosperma  | Fabaceae       | 10          | 64.53                           | 645.3                                |
| 26      | Ctlora temata     | Fabaceae       | 25          | 2.94                            | 63.5                                 |
| 27      | Mucuna pruriens  | Fabaceae       | 41          | 4.8                             | 196.8                                |
| 28      | Rhynchosia minima  | Fabaceae       | 78          | 1.3                             | 101.4                                |

Table 2: Carbon sequestration in the study area

| Sr. No. | Botanical Name   | Family         | Plant Count | Carbon Sequestration/Year In Kg | Total Carbon Sequestration/Year In Kg |
|---------|------------------|----------------|-------------|---------------------------------|--------------------------------------|
| 29      | Pongamia pinnata  | Fabaceae       | 12          | 52.3                            | 627.6                                |
| 30      | Gulchinia glauca  | Malpighiaceae  | 10          | 7.6                             | 76                                   |
| 31      | Abrus indicum     | Malvaceae      | 25          | 2.8                             | 70                                   |
| 32      | Hibiscus rosa-sinensis | Malvaceae    | 30          | 22.3                            | 713.6                                |
| 33      | Azadina indica    | Malvaceae      | 12          | 35.4                            | 424.8                                |
| 34      | Tinospora cordifolia | Menispermaceae | 35          | 39.25                           | 1373.75                              |
| 35      | Acacia arabica    | Mimosaceae     | 20          | 50.80                           | 1012.6                               |
| 36      | Prosopis julifora | Mimosaceae     | 10          | 35.2                            | 352                                  |
| 37      | Pithecolobium dulce | Mimosaceae     | 8           | 48.5                            | 388                                  |
| 38      | Ficus carica      | Moraceae       | 12          | 80.15                           | 961.8                                |
| 39      | Ficus benghalensis | Moraceae       | 2           | 100.5                           | 201                                  |
| 40      | Ficus religiosa   | Moraceae       | 2           | 95.6                            | 191.2                                |
| 41      | Eugenia jambolana  | Myrtaceae      | 4           | 85.2                            | 340.8                                |
| 42      | Castelodendron lanceolatus | Myrtaceae | 12          | 32.1                            | 385.2                                |
| 43      | Passiflora edulis | Myrtaceae      | 2           | 35.25                           | 70.56                                |
| 44      | Neolimus nuckleri | Nympthaceae    | 150         | 2.9                             | 435                                  |
| 45      | Cynodon dactylon  | Poaceae        | 400         | 1.3                             | 480                                  |
| 46      | Andropogon sumatrensis | Poaceae     | 625         | 1.3                             | 563.5                                |
| 47      | Setaria intermedia | Poaceae        | 300         | 1.5                             | 450                                  |
| 48      | Dentrostachys strictus | Poaceae     | 30          | 4.8                             | 144                                  |
| 49      | Potamogeton natans | Potamogetonaceae | 40          | 2.4                             | 96                                   |
| 50      | Anthocephalus cadamba | Rubiaceae     | 5           | 100.65                          | 301.95                               |
| 51      | Itua parviflora   | Rubiaceae      | 30          | 22.1                            | 663                                  |
| 52      | Citrus limon      | Rutaceae       | 2           | 30.45                           | 78.9                                 |
| 53      | Aegle marmelos   | Rutaceae       | 4           | 89.2                            | 276.8                                |
| 54      | Sapindus laurifolius | Sapindaceae  | 2           | 80.38                           | 161.16                               |
| 55      | Mimusops elongipetala | Sapindaceae  | 4           | 78.56                           | 314.24                               |
| 56      | Alangus exselsa  | Simaroubaceae   | 3           | 105.2                           | 315.6                                |
| 57      | Datura stramonium | Solanaceae     | 10          | 9.54                            | 95.4                                 |
| 58      | Tecoma grandis    | Verbenaceae    | 10          | 86.58                           | 866.5                                |
| 59      | Lantana camara   | Verbenaceae    | 30          | 76.96                           | 319.8                                |

Total 2948 18724