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CARBON SEQUESTRATION POTENTIAL AND THE PSYCHOLOGICAL IMPACTS OF GREEN SPACES / URBAN PARKS (CHH. SAMBHAJI GARDEN AND CHITTARANJAN VATIKA, PUNE).

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Abstract

The concentration of Carbon di-oxide has been increasing progressively for last two centuries resulting in climate change. To mitigate this, there are two alternatives by which we can reduce CO2; one is to decrease carbon emissions and another one is to increase carbon sink. Therefore, this study is going to focus on carbon pool, specifically in terms of urban parks vegetation and the impacts of green spaces on minds of common man. As we know, urban trees can help to mitigate climate change by sequestering atmospheric carbon. Thus, the need of the hour is to find ways and means for reducing the higher concentration of GHG's.

Urban parks and gardens are considered as lungs of the cities & have the ability to remove significant amounts of air pollutants, therefore improving environmental quality (Nowak et.al, 2006) & providing a wide variety of ecological and psychological services.

In this study, GPS Instrument and GIS-Arc view 9.3 to 10.1, - a recent software of Geographic Information System (GIS) were used as measuring. This research process helps in planning and management of green spaces and also helping to improve the psychological health of the people. In both the gardens, it is found that Indigenous plant species even though present in less number sequester more carbon-dioxide.

Keywords: *Carbon sinks, Carbon sequestration, Psychological health, Sustainable Development, GPS, GIS- Arc view*

1. Introduction

Changes in Nature are quite obvious and they are the fundamental characteristics of the environment. But today various human activities are responsible for accelerating these changes. The scientific evidence suggests that the earth's climate is changing, the atmosphere is warming and this trend will continue1. By the year 2050, scientists predict that the world will be warmer by an average of between 1.5 and 4.50C. Carbon dioxide, which remains in the atmosphere for around 200 years, is responsible for more than 55% of the current global warming from GHGs produced by human activities2. Its concentration has increased by more than 30 % since pre-industrial times (around 1750), and currently increases by 1 % every year. Since the early 20th century, Earth's mean surface temperature has increased by about 0.8 °C (1.4°F), with about two-thirds of the increase occurring since 1980. Warming of the climate system is unequivocal, and scientists are more than 90% certain that it is primarily caused by increasing concentrations of greenhouse gases produced by human activities such as the burning of fossil fuels and deforestation[3-7]. These findings are recognized by the national science academies (NSA) of all major industrialized nations. Reducing the amount of future climate change is called mitigation of climate change. The IPCC defines mitigation as activities that reduce greenhouse gas (GHG) emissions[8], or enhance the capacity of carbon sinks to absorb GHGs from the atmosphere [3,4]. Climate mitigation includes acts to enhance natural sinks, such as reforestation. Currently, emissions of CO_2 are increasing globally and are projected to double over the next century. Therefore, Climate change and its impacts must be studied holistically and thoroughly, requiring integration of climate, plant, ecosystem and soil sciences[9]. To cope with the increasing carbon dioxide problem, the emerging trend is to reduce the excess carbon level in the environment and its sequestration by using the natural sources like forest ecosystems[10-12]. Carbon sequestration in soils, grasslands and woody perennials, and the transfer of carbon credits through market structures, represent win-win opportunity. Among the alternatives, tree planting offers perhaps the greatest potential. There is also considerable evidence that urban gardens and large landscaping projects in developing countries provide substantial benefits to the environment and national economies [13, 14.]

A major part of the globe's terrestrial carbon, is sequestered in the standing biomass. Carbon sequestration is the extraction of the atmospheric carbon dioxide and its storage in terrestrial ecosystems for a very long period of time. Trees, through their growth process, act as sink for atmospheric carbon. Therefore, growing trees in urban areas can be a potential contributor in reducing the concentration of CO2 in atmosphere by its accumulation in the form of biomass[15,16]. In terms of atmospheric carbon reduction, trees in urban areas offer the double benefit of direct carbon storage and stability of natural ecosystem with increased recycling of nutrient along with maintenance of climatic conditions by the biogeochemical processes [9]. This study is going to focus on carbon pool, specifically in terms of above ground biomass of urban parks vegetation.

2. Materials & Methods:

The project is carried out in Sambhaji Garden and Chittaranjan Vatika viz. Dr. Chima Garden. The Latitude of Sambhaji Park is 18°52'05" N and the Longitude is 73°08'47" E whereas the Latitude of Chittaranjan Vatika is 18°31'56" N and the Longitude is 73°50'19" E. GPS Instrument was used for measuring latitude and longitude of each and every tree and GIS-Arc view 9.3 to 10.1, - a recent software of Geographic Information System (GIS) was used for locating the trees on map which gave clear idea where was exact location of each tree in the garden. In the present study, GIS was used as a complimentary technique along with field measurement techniques to obtain more accurate and precise calculation and interpretation of different layers including above, below ground biomass and also soil organic carbon[17].

Questionnaire was prepared and got it filled by the residence coming to the park and is analysed. A sample size of 50 (persons) is considered for both the gardens and results were analysed.

3. Sampling design:

The methods suggested by Ravindranath and Ostwald (2008), were used for measuring the above and belowground biomass and estimation of carbon pool. Random sampling technique was used to collect soil samples in both the study areas as it was a cost effective [1-2]. As the study areas were small in size, each and every tree is sampled for various parameters.

Soil organic carbon is normally estimated to a depth of 0–30 cm since most of it is present in the top layers and root activity is also concentrated in this horizon. Wet digestion or titrimetric determination method, which is also cost-effective procedure, is to estimate the organic carbon content of soil[18].

Data recording formats as per Ravindranath and Ostwald (2008) have been used for trees and shrub species in sample gardens. Above ground biomass carbon pool was estimated based on data taken in sample areas for carbon storage pools including live tree aboveground biomass, tree belowground biomass, and soil. All samples were taken in the year 2011-12 from December to April. Each and every plant species and individuals were sampled. All tree positions were recorded using a GPS unit and later were geo-referenced to the land-cover maps. Each plant was measured for its GBH (cm) and height (m)[19] .

4. Estimation of carbon stocks:

Terrestrial vegetation biomass can be divided into above-ground and below-ground carbon stocks/ pools. The analysis and calculation of carbon stocks involve conversion of field and laboratory estimates of various parameters from sample plots, such as diameter at breast height (DBH), height, wood Density values [14] and soil organic carbon content, into tonnes of carbon per hectare using different methods. The carbon pools for which the stocks are to be estimated are:

- Above-ground biomass
- Below-ground biomass
- Soil organic carbon

5. Soil organic carbon at 0.30 m:

During the present investigation 10 random samples were collected and analyzed to assess for soil organic C[17].Above and below ground carbon pool: Urban green space can play a critical role in helping to reduce increasing levels of atmospheric CO2, as well as provide a wide variety of ecological services and amenities to communities. The above, below-ground and total carbon pool in both the study areas[20] (Sambhaji garden and Chittaranjan Vatika) were analysed.

6. RESULT & DISCUSSIONS

In Sambhaji garden (Figure 1.1) Cassia siamea (exotic species) showed the highest biomass (11.79 tonnes) followed by other exotic species Spathodia companulata (6.93 tonnes). These exotic species were planted in more number as they grow very fast and increases the green cover very soon. The species like Syzigium cumini (6.82 tonnes) and Ficus religiosa (5.18 tonnes) sequestered highest amount of carbon among the native species. In this garden most of the species were exotics.

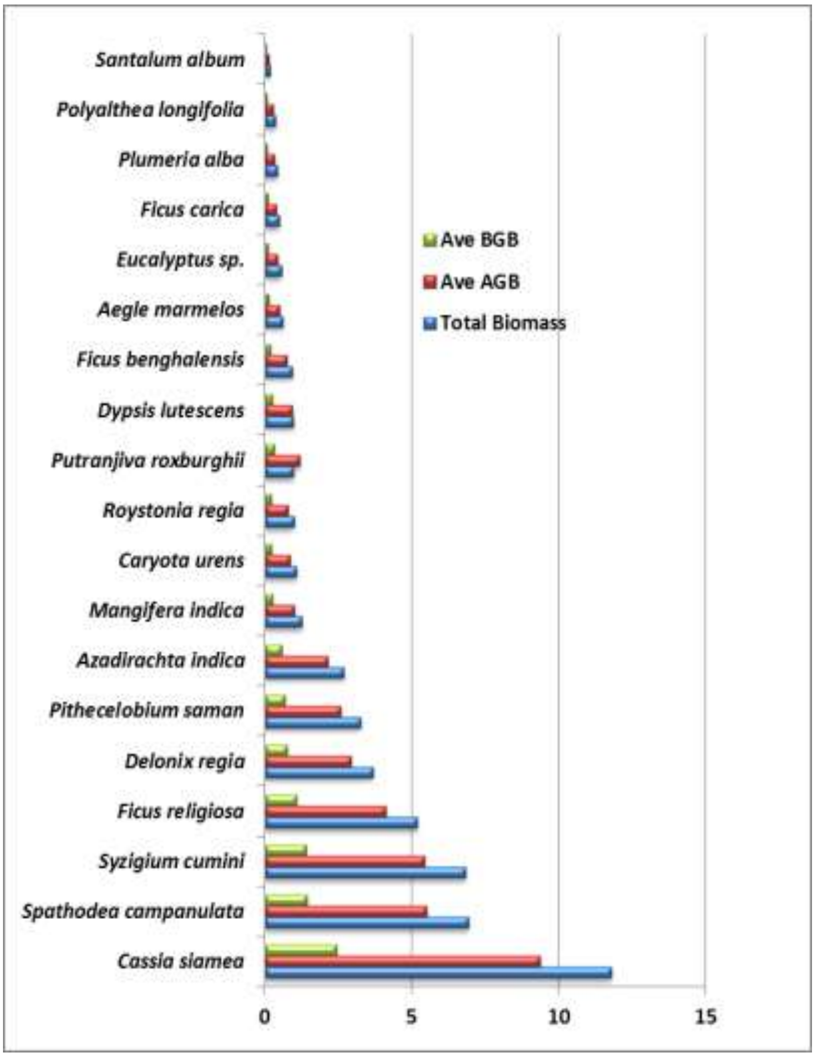


Figure 1.1: Species wise distribution of AGB, BGB and total biomass in Sambhaji Garden

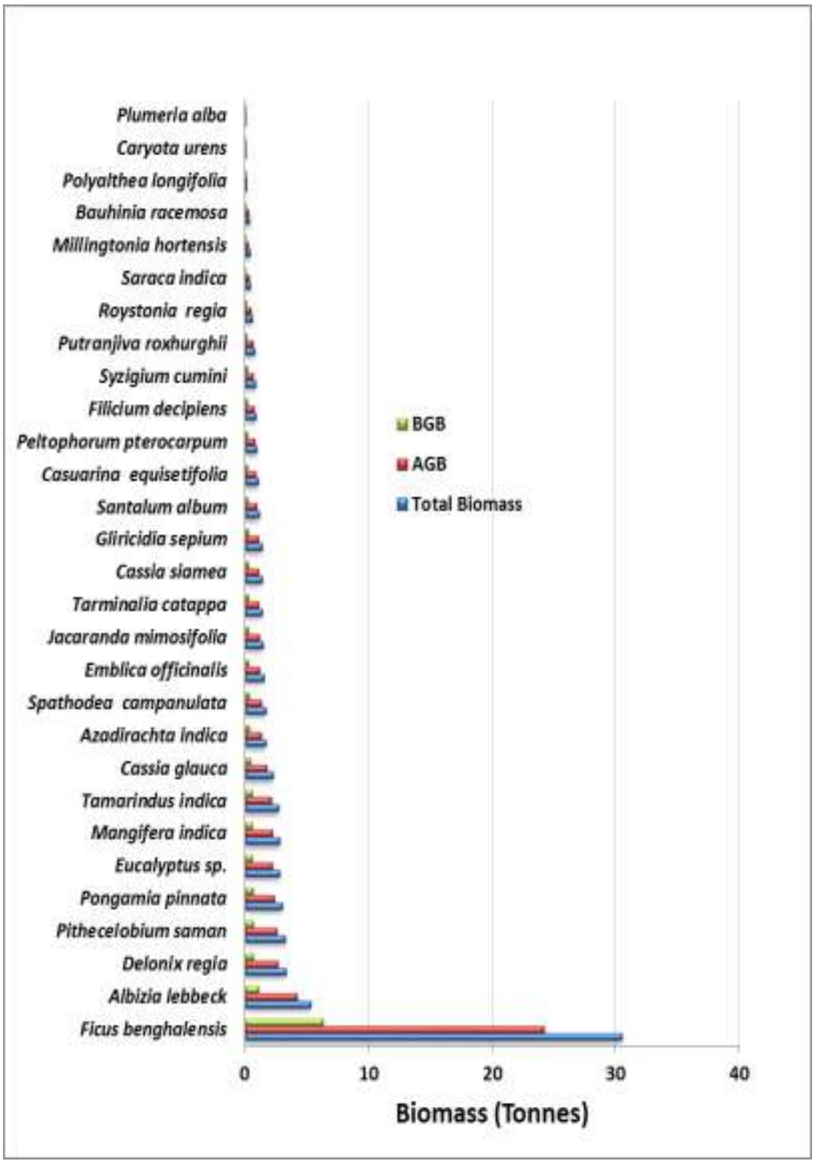


Figure 1.2: Species wise distribution of AGB, BGB and total biomass in Chittaranjan Vatika

In Chattaranjan Vatika (Figure 1.2) the native species have shown dominance in amount of carbon sequestered. Though very few in number (5 individuals), Ficus benghalensis showed (Figure 1.3) the highest biomass (30.49 tonnes) followed by Albizia lebbeck (5.32 tonnes in 02 individuals).

These native species were present before the establishment of the garden. However, the numbers of exotic species are more as compare to natives. The species like Delonix regia (3.33 tonnes) and Pithecelobium saman (3.26 tonnes) sequestered highest amount of carbon among the exotic species.

There is no correlation between number of individuals and amount of carbon sequestered (Figure 1.3). In Chittaranjan Vatika, total amount of carbon sequestrated was 387405 tonnes (aboveground) having 604 total numbers of individuals, whereas, in Sambhaji Garden, it was234769 tonnes having 372 individuals (Figure 1.4 and 1.5).

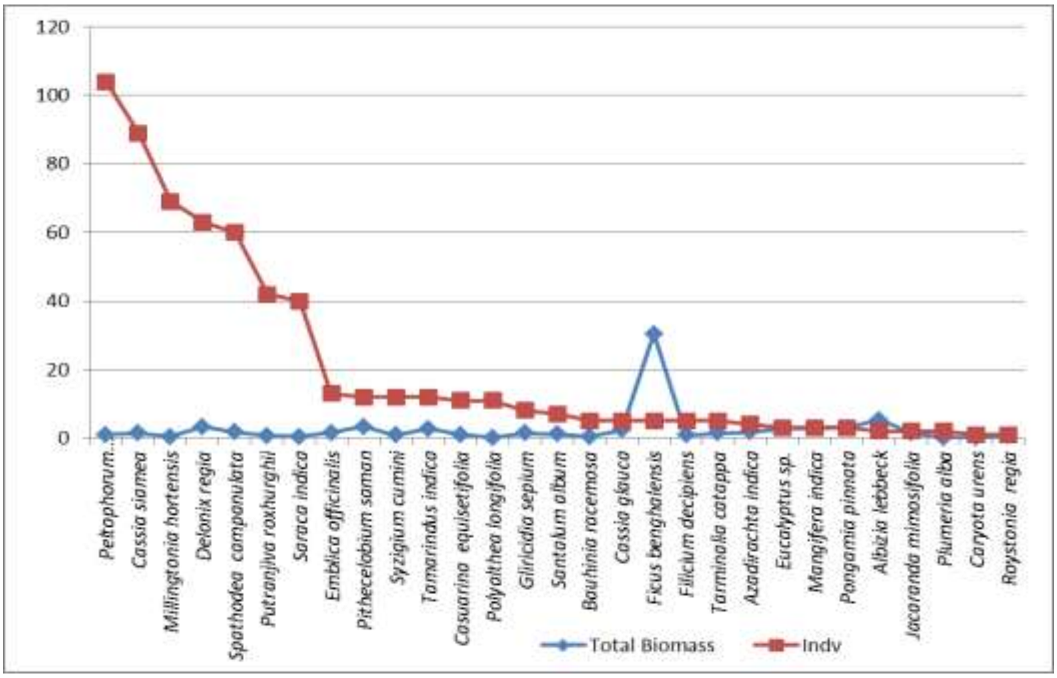


Figure 1.3 :Correlation between number of individuals and amount of carbon sequestered in Chittaranjan Vatika.

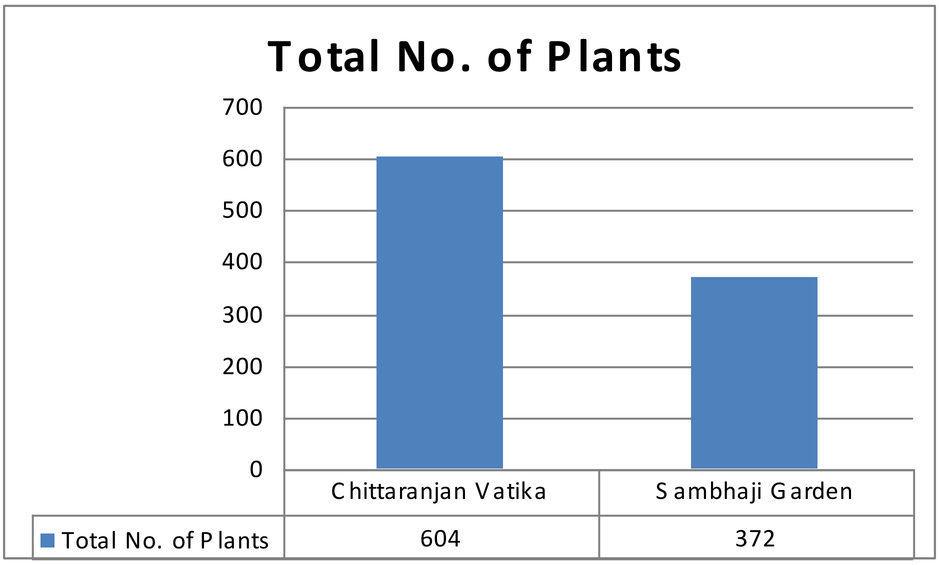


Figure 1.4: Total number of individuals in sampled gardens

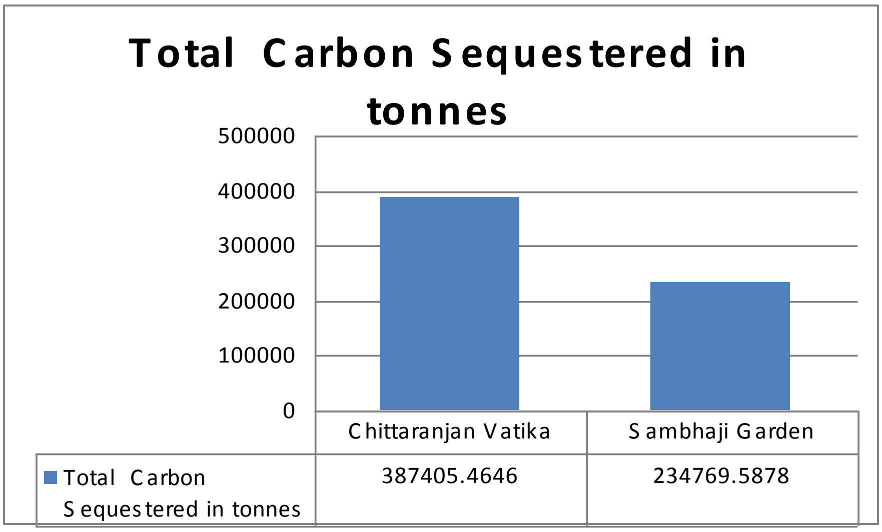


Figure 1.5: Total carbon sequestered (Tonnes) in sampled gardens

GIS interpretation of above and below ground distribution of carbon:

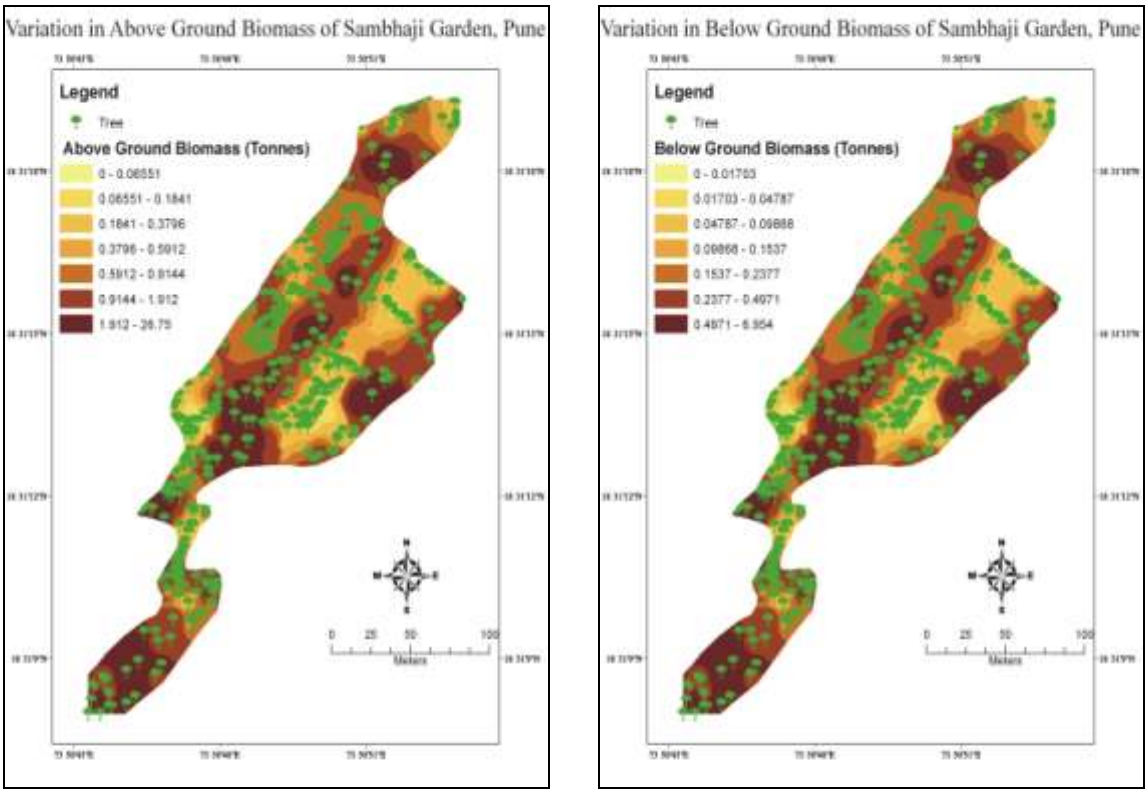


Figure 1.6: Distribution of above and belowground biomass in Sambhaji Garden.

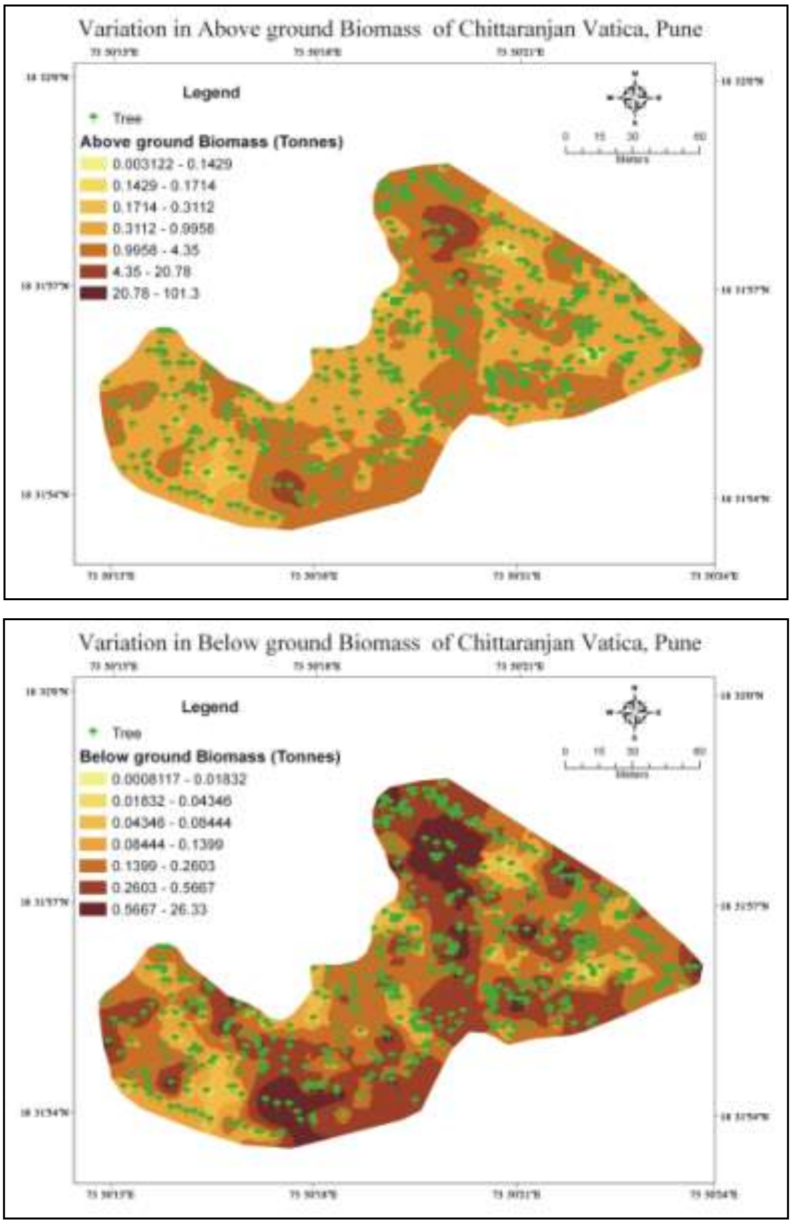


Figure 1.7: Distribution of aboveground & belowground biomass in Chittaranjan Vatika.

Arc view 9.2, as a recent software of Geographic Information System (GIS) was used for better analyzing, interpretation and eventually conceptualizing of above and below ground carbon sequestration in the entire area of Sambhaji Garden and Chittaranjan Vatika, Pune. GIS based map shows the location and value of above and below ground carbon sequestration for each study area. Dark brown colour in the GIS maps shows more amount of carbon sequestration and it goes on reducing as the colour tends to light brown to yellow.

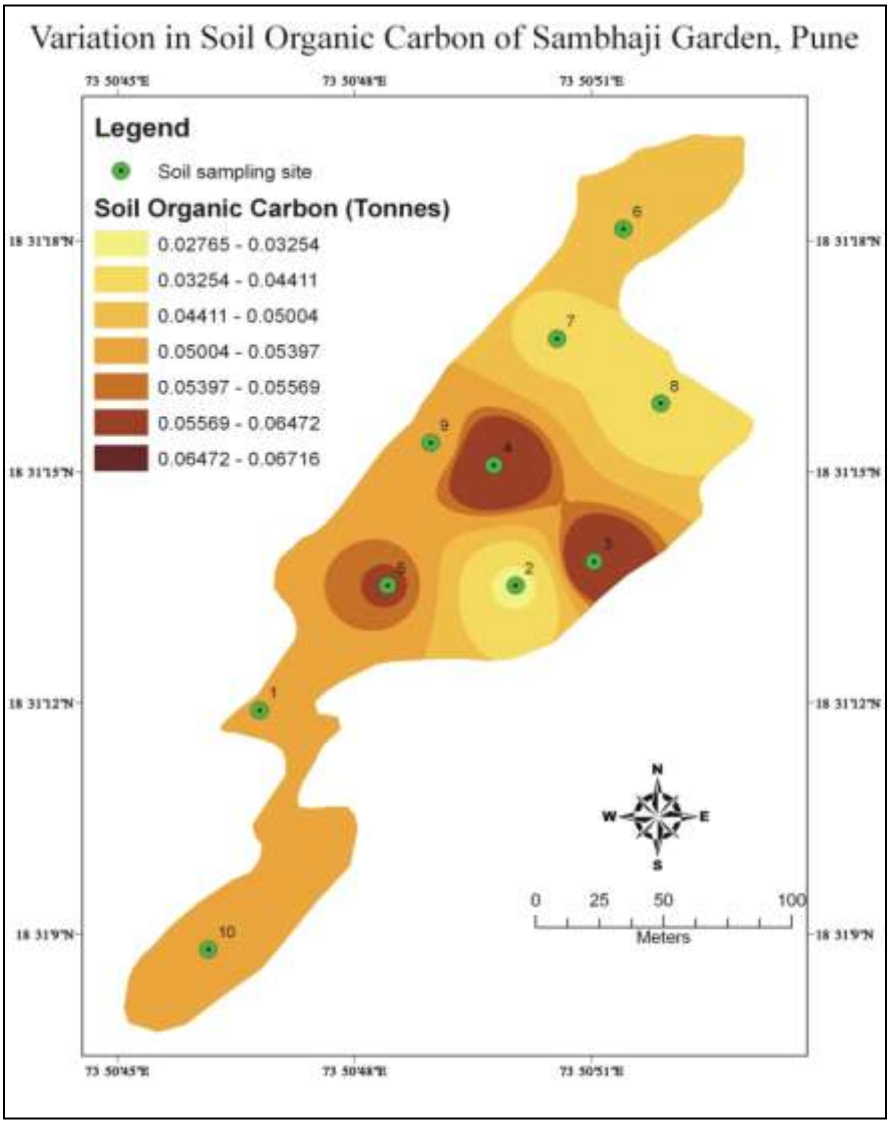


Figure 1.8: Variation in SOC in Sambhaji Garden

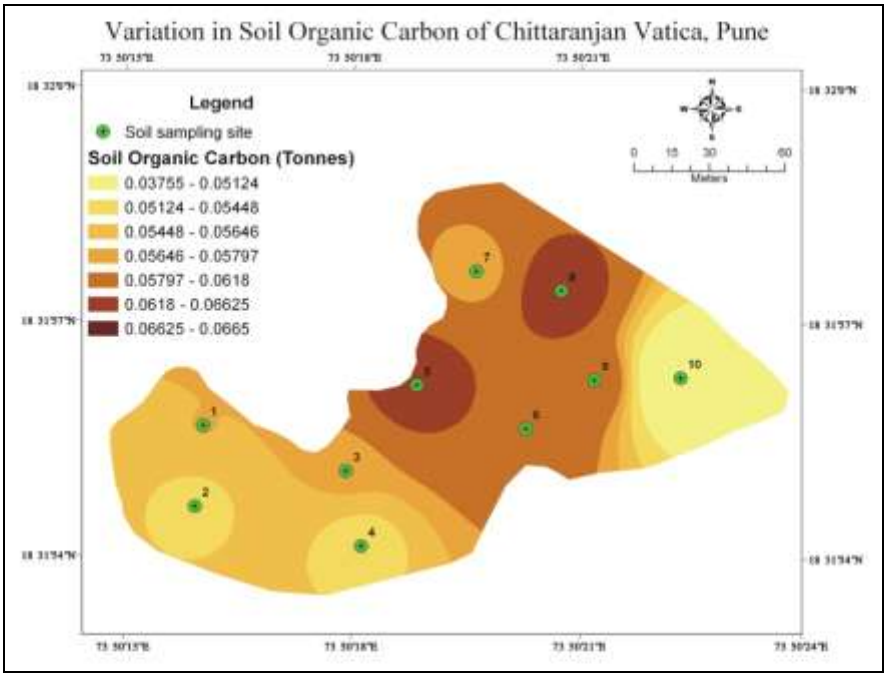


Figure 1.9: Variation in SOC in ChittaranjaVatika

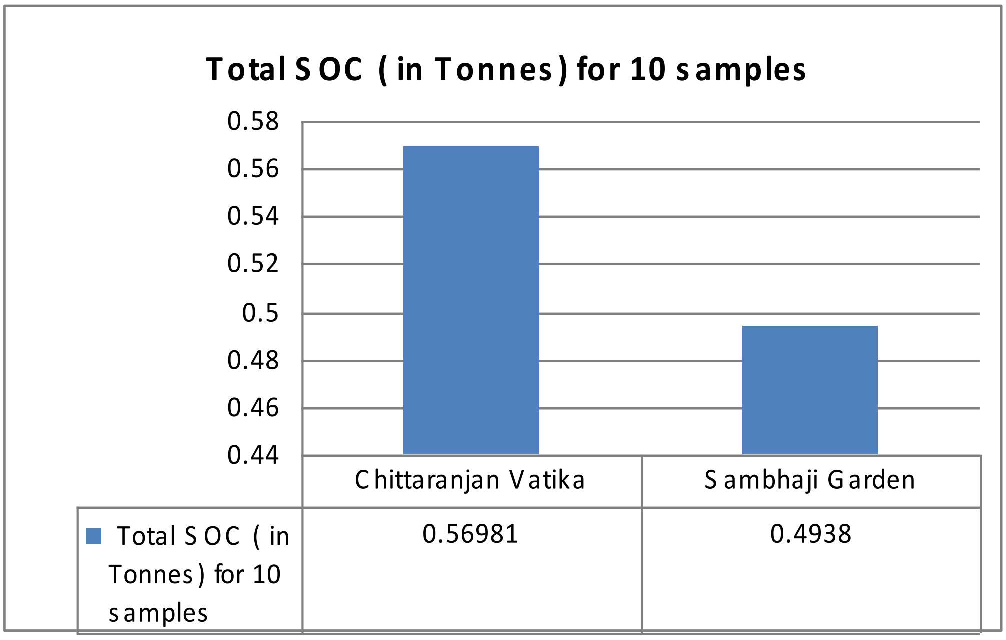
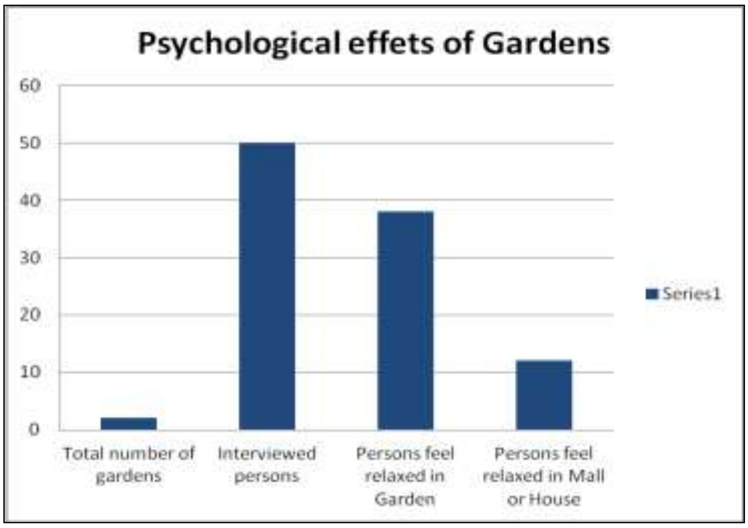
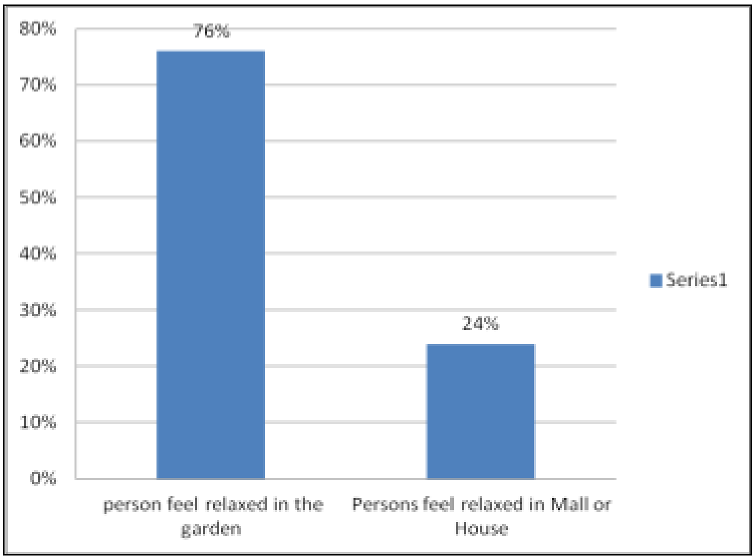


Figure 1.10: Variation in SOC in Chittaranjan Vatika & Sambhaji Garden

Figure 1.7 shows the IDW interpretation of the analyzed data for Chittaranjan Vatika which represents the distribution of above and belowground carbon pool. Here, the northern part of garden shows dark brown color representing more amount of carbon sequestered. This was because old and large trees are situated at this part of garden. This is clearly reflected in above and belowground figures. The faint yellow color represents lowest amount of carbon sequestered, because at this part trees are very sparse and lawn was present.

In view of this, the soil samples were collected at two different depths i.e. 0.15 m and 0.30 m. In both the areas, 10 samples/ site were collected. In Sambhaji garden, at 0.30 m depth total 0.4938 tonnes of soil carbon was recorded for 10 samples (Figure. 1.8) and in Chittaranjan Vatika at 0.30 m depth, total 0.56981 tonnes of soil carbon (Figure 1.9) was recorded. In Sambhaji Garden, the plot/ sample number 1,3,4 and 5 showed highest amount of soil organic carbon at 0.30 m depth; whereas in Chittaranjan Vatika, the plot/ sample number 5,6,8 and 9 showed highest amount of soil organic carbon at 0.30 m depth.





1.11: Analysis of questionnaire

4. CONCLUSIONS

Millions of metric tons of C currently stored by urban trees is a strong argument for at least maintaining the present urban forest structure. The loss of urban trees without replacement will act as a net C source to the atmosphere [21, 22,] both directly and indirectly. Establishing more properly chosen and located urban trees[23], in addition to maintaining the present structure, can make urban forests a larger sink for atmospheric C, along with producing other urban forest benefits [24, 25.]

The carbon pool was evaluated in two urban parks/gardens i.e. Chittaranjan Vatika and Sambhaji Garden in Pune city. The study was conducted for native and exotic tree species, when the trees were of different age. The above and below-ground biomass of each tree species was evaluated. Plant and soil carbon concentrations and carbon pools were estimated.

Major conclusions of this study are:

The vegetation of Chittaranjan Vatika was dominated by Cassia Siamia, Delonix regia, Milintona hotensis, Putranjiva roxburghii,, Peltoforum mermi, Saraca indica, Spathodea campanulata. Of which Ficus benghalensis showed highest carbon sequestration i.e. 30.49 tonnes (aboveground + belowground) followed by Albizia lebbeck (5.32 tonnes), Delonix regia (3.33 tonnes), and Pithecelobium dulce (3.26 tonnes).

The vegetation of Sambhaji Garden was dominated by dominated by Cassia siamea, Spathodia campanulata, Syzigium cumini, Ficus religiosa, Delonix regia, Pithecelobium saman, Polyalthea longifolia, Roystonia regia Mangifera indica, Santalum album, and Ficus religiosa. Of which Cassia siamia showed highest carbon sequestration i.e. 11.79 tonnes (above + belowground) followed by Spathodia campanulata (6.93 tonnes), Syzigium cumini (6.82 tonnes), Ficus religiosa (5.18 tonnes) and Delonix regia (3.68 tonnes).

In Chittaranjan Vatika, the carbon pool in the soil layer (0-30 m depth) ranged from 3.755-6.623 tonnes and In Sambhaji Garden, it ranged from 2.765- 6.453 tonnes. In Chittaranjan Vatika, 387405 tons of sequestrated carbon (aboveground- AG) was recorded having 604 total number of plants and in Sambhaji Garden, 234769 tons of sequestered carbon (above ground- AG) was recorded and having 372 total number of plants.

In Sambhaji Garden, the plant species having an average height in between 6-10 meters show less amount of Carbon sequestration as compared to the plant species having an average height in between 11-15 meters. In Chittaranjan Vatika, same results were obtained like Sambhaji garden as far as Average height of Plant species is considered.

From the analysis of garden data, it is found that almost 38 persons=76% people (out of 50 interviewed) feel relaxed in the gardens and 12 persons == 24 % people feel relaxed in Mall or House. According to the survey, it is found that as the garden location is in heavily traffic areas with lots of noise, so, they feel peaceful in home.

There are many psychological impacts of green spaces which includes-

- Positive impact on moods and mind
- Promote health and relieve stress
- Well being of inhabitants, give feeling of relaxation
- Helps to reduce crime in cities [26]
- Reduces aggression and violence
- Helps in participating in outdoor activities
- Contact with nature reduces precursors to crime like stress and aggression , making people feel happier.
- Gives peace to mind

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