

# An assessment of seasonal variation of carbon emission and carbon sequestration in rural areas of Belagavi district, Karnataka

## ABSTRACT

**Introduction:** Carbon emission cause climate change by trapping heat and they also contribute to respiratory disease from smog and air pollution. **Therefore, reducing** carbon emission is important because it mitigates the effects of global climate change, improves public health and maintains biodiversity. In carbon sequestration process atmospheric carbon is taken up by trees, grasses and plants through photosynthesis.

**Aim:** Analyse the carbon emissions **and** estimate the carbon sequestration.

**Methodology:** The study was conducted at Golihalli and Bidi village of Belagavi district, Karnataka in India to measure the carbon emission level through Air Quality Monitor and CO meter for one year. The carbon sequestration was assessed by non-destructive method.

**Results:** An annual mean concentration of CO<sub>2</sub> in Golihalli village was 924.33 ppm while in Bidi village 929.9 ppm and also the mean concentration of CO was 25.7 ppm in Golihalli village whereas 25.8 ppm in Bidi village. The mean concentration of PM<sub>2.5</sub> was 57.8 µm<sup>3</sup> and PM<sub>10</sub> was 107.5 µm<sup>3</sup> in Golihalli village however PM<sub>2.5</sub> was 57.9 µm<sup>3</sup> and PM<sub>10</sub> was 108 µm<sup>3</sup> in Bidi village. During the observation period, the maximum carbon emission concentration was measured in summer season and the minimum in rainy season. The largest value of carbon sequestration was seen in *Tamarindus indica* (530.22 gm) in Bidi village and *Azadirachta indica* (519.77 gm) in Golihalli village.

**Conclusion:** The carbon emission concentration was exceeding the safe level in both villages because of rural people's day-to-day activities and vehicular pollution. The trees with higher age and DBH have more carbon sequestration which could help in mitigate the effects of carbon emitted in the village.

**Keywords:** Carbon dioxide (CO<sub>2</sub>), Carbon emission, Carbon monoxide (CO), Carbon sequestration, Diameter at Breast Height (DBH), Particulate Matter (PM<sub>2.5</sub> and PM<sub>10</sub>).

## INTRODUCTION

The problem of carbon emission has become very serious today. It refers to the very bad condition of environment in terms of quantity and quality. Carbon emission is the release of carbon into the atmosphere which cause climate change, global warming, melting of the polar ice caps, rising of sea levels by trapping heat. The amount of carbon emission in the atmosphere has increased due to the industrial revolution. Global carbon emissions were 150 times increased from 1850 (198 Mt) to 2011 (32274 Mt) due to industrialization and population growth. Our India is the third largest carbon emitter after China and the US (Gordon *et al.*, 2019).

The main sources of carbon emission are both natural and man-made sources. Natural sources include decomposition, volcanoes, wildfires, respiration etc. Man-made sources include industries, deforestation, transportation, soil cultivation, biomass burning etc. (Dash and Dash, 2015). Carbon emission pollutants can either be particles, liquids or gaseous in nature. In developing countries of Asia, people have exposure to carbon emission that is largely caused by particulate matter (PM), Carbon dioxide (CO<sub>2</sub>) and Carbon monoxide (CO) (Roy *et al.*, 2022).

The particulate matter is an atmospheric carbon particle which is a mixture of solid particles and liquid droplets found in the air. Some particles such as dust, dirt, soot, smoke, large and dark enough to be seen with the naked eye. Particulate matter (PM<sub>2.5</sub>) and particulate matter (PM<sub>10</sub>) are more dangerous particles which effects to cardiovascular and respiratory systems (Singh *et al.*, 2021). Carbon dioxide is an important heat-trapping (greenhouse) gas, which is released through natural process respiration, combustion and metabolic activity. It can lead to headache, dizziness, sweating, restlessness, tiredness, difficulty in breathing, increased heart rate and blood pressure.

Carbon monoxide is an odorless, colorless, tasteless and toxic air pollutant formed by the incomplete combustion of carbon containing fuels. The low concentration of carbon monoxide can cause fatigue and chest pain. The higher concentration of carbon monoxide can cause impaired vision, headache, dizziness and nausea. The prolonged exposure of carbon monoxide can cause memory problems, difficulty in concentrating and even death (Mutahi *et al.*, 2021). Other pollutants like Nitrogen dioxide (NO<sub>2</sub>) and Sulfur dioxide (SO<sub>2</sub>) are heavy and poisonous gas formed by fuel burning which irritates the respiratory tract, coughing, asthma and chronic lung disease (Dash and Dash, 2015).

Reducing carbon emission is important because it mitigates the effects of global climate change, improves public health, boosts the global economy and maintains biodiversity. Current

strategies for coping with carbon emission include reducing fossil fuel combustion as well as curbing emission of other GHGs and increasing carbon sequestration (Mangalssery *et al.*, 2014). One of the easiest ways to reduce the carbon emission concentration in the atmosphere is carbon sequestration.

Carbon sequestration is a natural or artificial process by which carbon is removed from the atmosphere and held in solid or liquid form. It is the process of capturing and storing atmospheric carbon. In this process atmospheric carbon is taken up by trees, plants and other grasses through photosynthesis and stored as carbon in biomass (trunks, branches, foliage and roots) and soil. The carbon sequestration capacity of trees depends upon its age, height, girth size, diameter at breast height and biomass (Maji *et al.*, 2017). Planting trees which sequester carbon in large amount will reduce the atmospheric carbon emission (SaraI *et al.*, 2017). Hence, the present study was to analyse the carbon emissions and to estimate the carbon sequestration influenced by the microclimate in the Golihalli and Bidi village of Belagavi district, Karnataka, India.

## MATERIALS AND METHODS

### Study area:

The measurement of carbon emission and carbon sequestration has been carried out in Golihalli and Bidi village of Belagavi district, Karnataka, India [Fig. 1].

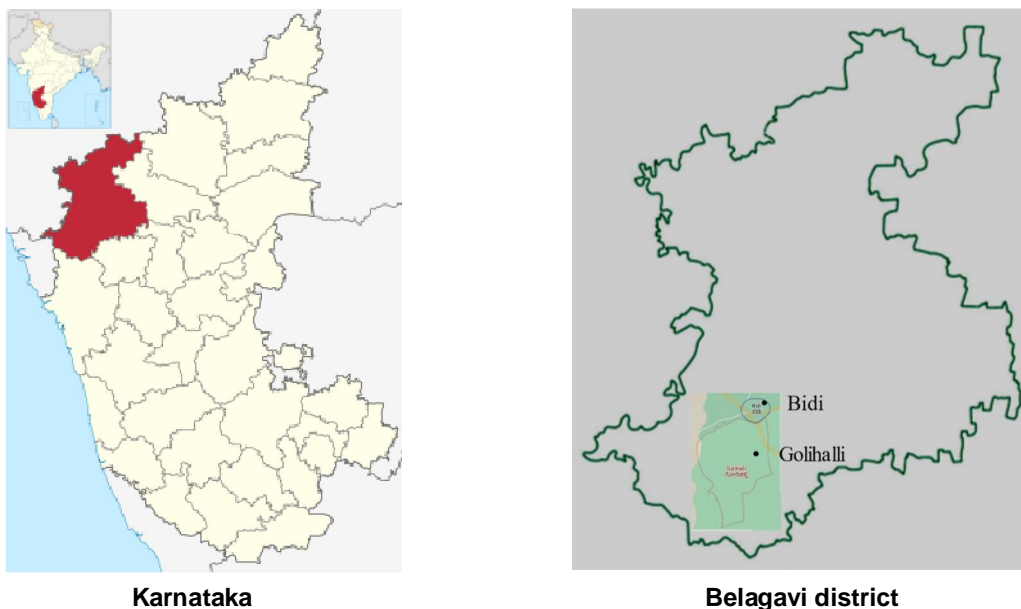
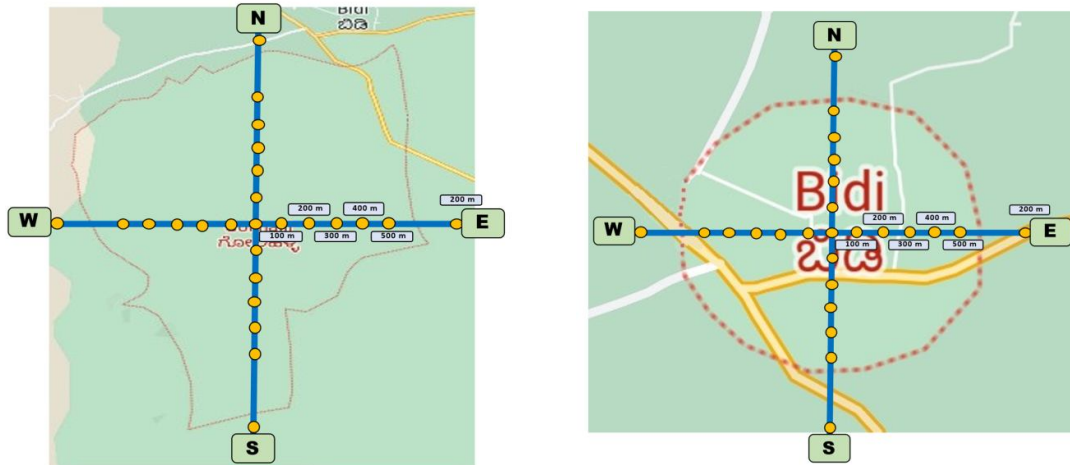


Fig. 1: Golihalli and Bidi village in Belagavi district of Karnataka, India

### Sampling design for measurement of carbon emission:

The selected parameters were horizontally measured at centre of the village, in a range of 100 m, 200 m, 300 m, 400 m, 500 m away from the centre of the village and 200 m away from the last house of the village in all four directions (North, East, West and South) [Fig. 2].



**Fig. 2: Horizontal measurement at Golihalli and Bidi village**

The selected parameters like temperature, relative humidity, Carbon dioxide ( $\text{CO}_2$ ), Particulate Matter ( $\text{PM}_{2.5}$ ) and Particulate Matter ( $\text{PM}_{10}$ ) were measured by Air Quality Monitor and Carbon monoxide (CO) were measured by CO meter for one year from October 2021 to September 2022 [Fig. 3].



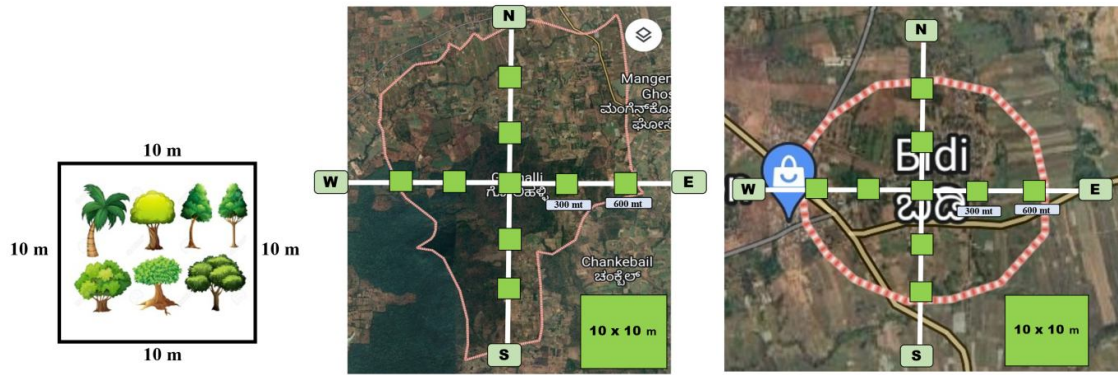
**Air Quality Monitor**

**CO meter**

**Fig. 3: Monitoring instruments**

**Sampling design for estimation of carbon sequestration:**

The carbon sequestration was assessed by non-destructive method which was estimated through calculating the biomass. The amount of carbon was measured based on the amount of standing woody biomass of trees in Golihalli and Bidi village of Belagavi district. Initially the trees were sampled by quadrat method. Quadrates of size 10 x10 m were taken at centre of the village, in a range of 300 m and 600 m away from the centre of the village in all four directions (North, East, West and South) [Fig. 4].



**Fig. 4: Quadrat method**

A non-destructive method of biomass estimation was used to measure the tree height and Girth at Breast Height, approximately 1.3 m from the ground by measuring tape. A brief description of the used formulae for carbon sequestration estimation in the analysis is given below:

- Diameter at Breast Height (DBH) =  $\frac{\text{Girth at Breast Height}}{\pi}$
- Above Ground Biomass (AGB) = Volume x Wood density
  - Volume =  $\mu hr^2$
  - Wood density = 0.6 gm/cm (0.06 kg/m<sup>3</sup>)
- Below Ground Biomass (BGB) = AGB X 0.26
- Total Biomass = AGB + BGB
- Carbon Storage = Biomass X 50 %
- Carbon Sequestration = Carbon Storage X 3.66

### **Statistical analysis:**

The statistical variations in temperature, relative humidity, carbon dioxide, carbon monoxide, particulate matter (PM<sub>2.5</sub>) and particulate matter (PM<sub>10</sub>) between seasons were assessed through one-way ANOVA. A regression analysis was performed to study the relationship between age of trees and carbon sequestration and also DBH of trees and carbon sequestration per village. Pearson's correlation coefficients were used to determine the strength of association between different parameters of trees such as age of tree, DBH of tree, biomass, carbon storage and carbon sequestration in trees.

## RESULTS AND DISCUSSION

### Measurement of carbon emission:

Table-1 indicated the monthly mean concentration of carbon emission at Belagavi district for one year from October 2021 to September 2022. The annual mean temperature of Golihalli village was 26.3°C and Bidi village was 26.1°C whereas the annual mean percentage of relative humidity in Golihalli village was 63.5 per cent and in Bidi village was 64.6 per cent. The annual mean concentration of carbon dioxide in Golihalli village was 924.3 ppm while in Bidi village 929.9 ppm and also the annual mean concentration of carbon monoxide was 25.7 ppm in Golihalli village whereas 25.8 ppm in Bidi village. The annual mean concentration of particulate matter (PM<sub>2.5</sub>) was 57.8 µm<sup>3</sup> and particulate matter (PM<sub>10</sub>) was 107.5 in Golihalli village however particulate matter (PM<sub>2.5</sub>) was 57.9 µm<sup>3</sup> and particulate matter (PM<sub>10</sub>) was 108 µm<sup>3</sup> in Bidi village [Fig. 5]. The carbon emission concentration was exceeding the safe level in both villages because of rural people's day-to-day activities and vehicular pollution. Similarly, an overall mean value of CO<sub>2</sub> concentration was higher than the global mean atmospheric CO<sub>2</sub> value (Anthwal *et al.*, 2015). The vertical carbon dioxide distributions were measured by Chiba *et al.* (2019). The CO<sub>2</sub> concentration in all over the India was gradually increased from the year 2010-2015 (Krishnapriya *et al.*, 2020). According to Singh *et al.* (2021) Delhi had highest diurnal and monthly mean PM<sub>2.5</sub> concentration during the year of 2014 – 2019.

### Seasonal variation of carbon emission:

During the observation period, the maximum mean temperature was measured in summer season that is 26.7 °C in Golihalli village and 26.5 °C in Bidi village and the temperature was minimum in rainy season that is 25.7 °C in Golihalli village and 25.5 °C in Bidi village [Fig. 6(a)]. Whereas the maximum mean percentage of relative humidity was measured in summer season that is 76.7 per cent in Golihalli village and 76.1 per cent in Bidi village and the relative humidity was minimum in rainy season that is 48.8 per cent in Golihalli village and 52.9 per cent in Bidi village [Fig. 6(b)]. The maximum mean concentration of carbon dioxide was measured in summer season that is 989.5 ppm in Golihalli village and 1007.3 ppm in Bidi village and the concentration was minimum in rainy season that is 881.5 ppm in Golihalli village and 874.5 ppm in Bidi village [Fig. 6(c)]. While the maximum mean concentration of carbon monoxide was measured in summer season that is 29.5 ppm in Golihalli village and 29.8 ppm in Bidi village and the concentration was minimum in rainy season that is 23.5 ppm in Golihalli village and 23.3 ppm in Bidi village [Fig. 6(d)].

The maximum mean concentration of particulate matter (PM<sub>2.5</sub>) was measured in summer season that is 69.5 µm<sup>3</sup> in both villages and minimum in rainy season that is 48.3 µm<sup>3</sup> in Golihalli village and 47.8 µm<sup>3</sup> in Bidi village [Fig. 6(e)]. However, the maximum mean concentration of particulate matter (PM<sub>10</sub>) was measured in summer season that is 126.5 µm<sup>3</sup> in Golihalli village and 124.3 µm<sup>3</sup> in Bidi village and the concentration was minimum in rainy season that is 97.8 µm<sup>3</sup> in Golihalli village and 96.5 µm<sup>3</sup> in Bidi village [Fig. 6(f)]. The maximum carbon emission concentration was measured in summer season and minimum in rainy season. Because, during rainy season the

rain water can dissolve atmospheric carbon. According to Chiba *et al.* (2019) the higher CO<sub>2</sub> concentration was observed during April to May and low during June to August. The tropospheric CO<sub>2</sub> concentration in all over the India was increased from the year 2010-2015 during September to March month and decreased during April to August month (Krishnapriya *et al.*, 2020). The highest mean concentration of GHGs were in pre-monsoon season and lowest in monsoon season (Metya *et al.*, 2021). The mean PM<sub>2.5</sub> concentration during the year of 2014 – 2019 was highest in the post-monsoon season and lowest in monsoon season (Singh *et al.*, 2021).

#### **Variation of carbon emission among seasons and villages:**

Table 2 shows the results obtained due to the application of one-way Analysis of Variance (ANOVA) test for different parameters based on monitoring seasons. The F value was calculated to be 14 for temperature which was found to be significant (at P<0.01) due to variation in season. Further, the F values computed as 114.34, 119.19, 362.87, 1128.89 and 89.85 for relative humidity, carbon dioxide (CO<sub>2</sub>), carbon monoxide (CO), particulate matter (PM<sub>2.5</sub>) and particulate matter (PM<sub>10</sub>) respectively due to variation in seasons were found to be highly significant (at P<0.01). This indicates that there exists a significant variation among the different parameters due to variation in seasons. Dash and Dash (2015) found the PM<sub>10</sub>, PM<sub>2.5</sub>, SO<sub>2</sub> and NO<sub>2</sub> concentrations were significantly varied based on the seasonal differences in their one-way ANOVA test considering data from March 2014 to February 2015 in India. According to Kumar and Dash (2018) found that, the concentration of PM<sub>10</sub>, PM<sub>2.5</sub>, SO<sub>2</sub> and NO<sub>2</sub> were found to be significant (P<0.01) due to the variations in seasons. The PM<sub>10</sub> and PM<sub>2.5</sub> concentrations in the atmosphere were found to be significant due to different seasons, stated by Roy *et al.* (2022).

#### **Estimation of carbon sequestration:**

Table- 3 indicated that estimated the carbon sequestration by 17 different species including 57 individual trees were assessed from Golihalli village and 16 different species including 44 individual trees were assessed from Bidi village. The estimated total biomass of the trees in Golihalli village was 0.91 kg and in Bidi village was 0.849 kg. The total carbon storage by the trees in Golihalli village was 456.74 gm and in Bidi village was 423.63 gm. The carbon sequestration of the trees in Golihalli village was 1671.62 gm and in Bidi village was 1550.52 gm. Among the 17 species, major carbon sequestering species were *Azdirachta indica* (Neem) that is 519.77 gm/tree which had the highest average age (50 years) and DBH (0.53 m) followed by *Tamarindus indica* (Tamarind) that is 438.27 gm/tree and *Cocos nucifera* (Coconut) that is 180.39 gm/tree in Golihalli village.

Whereas among the 16 species, the major carbon sequestering species were *Tamarindus indica* (Tamarind) that is 530.22 gm/tree which had the highest average age (47.8 years) and DBH (0.46 m) followed by *Azdirachta indica* (Neem) that is 495.4 gm/tree and *Cocos nucifera* (Coconut) that is 167.89 gm/tree in Bidi village [Fig-7]. The trees with higher age and DBH have more carbon sequestration. As a tree grows, it stores more carbon by holding it in its accumulated tissue. Maji *et al.* (2017) found that among road side plant species the major carbon sequestering species were *Ficus*

*religiosa* (Peepal tree) that is 86.67 gm/tree in Hooghly district of West Bengal. The *Millingtonia hortensis* (Cork tree) was sequestered carbon in large amount (52.583 kg/tree) in VIT University campus, Vellore of Tamil Nadu (Saral *et al.*, 2017). The highest carbon sequestering species were *Leucaena leucocephala* (Wild tamarind) that is 23.887 Mg/ha in the campus of Indian Institute of Management (IIFM), Bhopal of Madhya Pradesh (Dugaya *et al.*, 2020). The *Ficus benjamina* (Weeping fig) sequestered highest amount of carbon that is 30.53 tons in Amity University Campus Noida in Uttar Pradesh (Sharma *et al.*, 2021).

#### **Relationship between tree age and DBH with carbon sequestration:**

The regression analysis showed that there was highly significant positive correlation between average age of trees and carbon sequestration ( $R^2 = 0.886$ ) and also between average DBH of trees and carbon sequestration ( $R^2 = 0.891$ ) in Golihalli village [Fig-8 (a) & (b)]. Whereas in Bidi village, there was highly significant positive correlation between average age of trees and carbon sequestration ( $R^2 = 0.918$ ) and also between average DBH of trees and carbon sequestration ( $R^2 = 0.914$ ) [Fig-8 (c) & (d)].

The variation in average age and DBH of trees could explain 88.6% and 89.1% respectively variation in carbon sequestration in Golihalli village. Whereas the variation in average age and DBH of trees could explain 91.8% and 91.4% respectively variation in carbon sequestration in Bidi village. Regression model with age and DBH of tree were best fitted for estimation of carbon sequestration. Therefore, the age and DBH of trees can be a good predictor of carbon sequestration in trees in both villages. These results were substantiated by Arora *et al.* (2014) stated the allometric models were well fitted ( $R^2 = 0.94$ ) between carbon sequestration with age and DBH. According to Jithila and Prasadani (2018) assessed the DBH of trees had liner relationship with carbon sequestration ( $R^2 = 0.687$ ). Nirala *et al.* (2018) reported highly significant positive correlation ( $R^2 = 0.859$ ) between carbon sequestration and DBH in teak plantations.

#### **Strength of association between carbon sequestration and different parameters of tree:**

The Pearson's correlation analysis was performed to determine the strength of association between different parameters. A significantly strong positive correlation was observed between carbon sequestration and other parameters such as average age ( $r = 0.94$ ), average DBH ( $r = 0.94$ ), total biomass ( $r = 1.00$ ) and carbon storage ( $r = 1.00$ ). Similarly, a significantly strong positive correlation was also noted between carbon storage and other parameters such as average age ( $r = 0.94$ ), average DBH ( $r = 0.94$ ) and total biomass ( $r = 1.00$ ). However, the total biomass was also significantly strong positive correlation with average age ( $r = 0.94$ ) and average DBH ( $r = 0.94$ ) and also average DBH was significantly strong positive correlation with average age ( $r = 1.00$ ) in Golihalli village.

A significantly strong positive correlation was observed between carbon sequestration and other parameters such as average age ( $r = 0.97$ ), average DBH ( $r = 0.96$ ), total biomass ( $r = 1.00$ ) and

carbon storage ( $r = 1.00$ ). Similarly, a significantly strong positive correlation was also noted between carbon storage and other parameters such as average age ( $r = 0.97$ ), average DBH ( $r = 0.96$ ) and total biomass ( $r = 1.00$ ). However, the total biomass was also significantly strong positive correlation with average age ( $r = 0.97$ ) and average DBH ( $r = 0.96$ ) and also average DBH was significantly strong positive correlation with average age ( $r = 1.00$ ) in Bidi village [Table-4]. If the tree age and DBH are increased then the biomass, carbon storage and carbon sequestration will also increase in tree. The total biomass of trees varied positively and linearly with diameter at breast height ( $r = 0.953$ ) by Bohre *et al.* (2014). According to Bhattacharya *et al.* (2020) there was a positive correlation between carbon stock and tree biomass ( $r = 0.865$ ). Behera *et al.* (2022) stated Pearson's correlation matrix established the positive relationship between growth performance and physiological traits of species with their capacity to sequester carbon.

## CONCLUSION

The mean concentration of carbon dioxide ( $\text{CO}_2$ ), carbon monoxide (CO), particulate matter ( $\text{PM}_{2.5}$ ) and particulate matter ( $\text{PM}_{10}$ ) were higher than the safe level in both villages because of rural people's day-to-day activities and vehicular pollution. The trees with higher age and DBH have more carbon sequestration which was in *Tamarindus indica* (Tamarind) and *Azdirachta indica* (Neem). Therefore, these plants are recommended for plantations in villages which can help in sequestering carbon and mitigate the effects of carbon emitted from the rural people's day-to-day activities and vehicles. Planting healthy and large number of trees helps to maximize the amount of carbon sequestration in the atmosphere which in turn improves the rural people's health.

## REFERENCES:

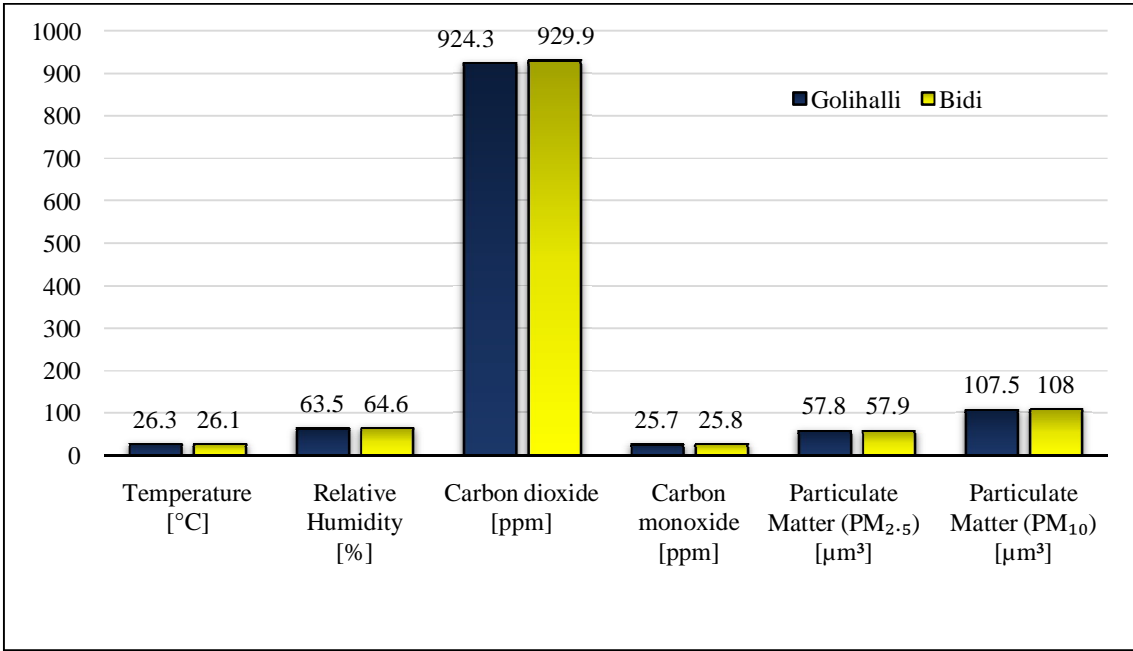
- Anthwal A, Joshi V, Joshi S C and Kuma K. Measurement of atmospheric carbon dioxide levels at Dokriani Bamak, Garhwal Himalaya, India. *Dynamics of Climate Change and Water Resources of North-western Himalaya*. 2015;23: 115-125.
- Arora G, Chaturvedi S, Kaushal R, Nain A, Tewari S, Alam N M and Chaturvedi O P. Growth, biomass, carbon stocks, and sequestration in an age series of *Populus deltoides* plantations in Tarai region of central Himalaya. *Turkish Journal of Agriculture and Forestry*. 2014;38: 550-560.
- Behera S K, Mishra S, Sahu N, Manika N, Singh S N, Anto S, Kumar R, Husain R, Verma A K and Pandey N. Assessment of carbon sequestration potential of tropical tree species for urban forestry. *ScienceDirect*. 2022;181(6): 1-18.
- Bhattacharya A K, Saikia A K, Takhelmayum M, Sarkar P. Carbon sequestration in the bio-edaphic ecosystem of National Highway-27 in Guwahati, Assam, India. *Heliyon*. 2020;6(1): 1-11.
- Bohre P, Chaubey O P and Singhal P K. Biomass production and carbon sequestration by *Pongamia pinnata* (Linn) Pierre in tropical environment. *International Journal of Bio-Science and Bio-Technology*. 2014;6(2): 129-140.
- Chiba T, Haga Y, Inoue M, Kiguchi O, Nagayoshi T, Madokoro H and Morino I. Measuring regional atmospheric CO<sub>2</sub> concentrations in the lower troposphere with a Non-Dispersive Infrared analyzer mounted on a UAV, Ogata village, Akita, Japan. *Atmosphere*. 2019;10(487): 1-17.
- Dash S K and Dash A K. Assessment of ambient air quality with reference to Particulate Matter (PM<sub>10</sub> and PM<sub>2.5</sub>) and gaseous pollutants (SO<sub>2</sub> and NO<sub>2</sub>) near Bileipada, Joda area of Keonjhar, Odisha, India. *Pollution Research*. 2015;34 (4): 817-824.
- Dugaya D, Srirag S, Pandey A K, Paul A, Shukla D D, Deo K, Sharma N, Verma S, Nagaria S, Guhaprasad S and Chaudhry P. Carbon sequestration potential of trees planted along roadsides: a case from Bhopal city, India. *International Journal of Environment*, 2020;9(2): 104-119.
- Gordon T, Balakrishnan K, Dey S, Rajagopalan S, Thornburg J, Thurston G, Agrawal A, Collman G, Guleria R, Limaye S, Salvi S, Kilaru V and Nadadur S. Air pollution health research priorities for India: Perspectives of the Indo-U.S. Communities of Researchers. *Environment International*. 2019;119: 100–120.
- Jithila P J and Prasad P K. Carbon sequestration by trees-a study in the western ghats, Wayanad region. *Indian Journal of Ecology*. 2018;45(3): 1-4.
- Krishnapriya M, Nayak R K, Allahudeen S, Bhuvanachandra A, Dadhwal V K, Jha C S, Sheshasai M V R, Sasmal S K and Prasad K V S R. Seasonal variability of tropospheric CO<sub>2</sub> over India based on model simulation, satellite retrieval and in-situ observation. *Journal of Earth System Science*. 2020;129 (2): 1-19.

- Kumar S D and Dash A. Seasonal variation of air quality index and assessment. *Global Journal of Environmental Sciences and Management*. 2018;4(4): 483-492.
- Maji A, Das M and Mukherjee A. A preliminary study on carbon sequestration potential of few roadside plant species of Pursurah area of Hooghly district, West Bengal (India). *Research Journal of Pharmaceutical, Biological and Chemical Sciences*. 2017;8(3): 2051- 2056.
- Mangalassery S, Dayal D, Meena S L and Ram B. Carbon sequestration in agroforestry and pasture systems in arid north-western India. *Current Science*. 2014;107(8): 1290-1293.
- Metya A, Datye A, Chakraborty S, Tiwari Y K, Sarma D, Bora A. and Gogoi N. Diurnal and seasonal variability of CO<sub>2</sub> and CH<sub>4</sub> concentration in a semi-urban environment of western India. *Scientific Reports*. 2021;11: 1-13.
- Mutahi A W, Borgese L, Marchesi C, Gatari M J and Depero L E. Indoor and outdoor air quality for sustainable life: A case study of rural and urban settlements in poor neighborhoods in Kenya. *Sustainability*. 2021;13: 1-18.
- Nirala D, Khanduri V P and Sankanur M S. Biomass and carbon stock assessment in different age group plantations of Teak (*Tectona grandis Linn. F.*) in Bhabar and Shivalik Regions of Uttarakhand. *International Journal of Bio-resource and Stress Management*. 2018;9(3): 379-382.
- Roy S, Chowdhury R and Purna P. Development of PM<sub>2.5</sub> concentration prediction model using machine learning approaches. In: *6th International Conference on Civil Engineering for Sustainable Development*, 10-12 February 2022, Khulna University of Engineering and Technology, Khulna, Bangladesh. 2022; pp. 1-10.
- Saral A M, Selcia S S and Devi K. Carbon storage and sequestration by trees in VIT University campus. *IOP Conference Series: Materials Science and Engineering*. 2017;263: 1-5.
- Sharma R, Pradhan L, Kumari M and Bhattacharya P. Assessment of carbon sequestration potential of tree species in Amity University campus Noida. *Environmental Sciences Proceedings*. 2021;3(52): 1-9.
- Singh V, Singh S and Biswal A. Exceedances and trends of Particulate Matter (PM<sub>2.5</sub>) in five Indian megacities. *Science of the Total Environment*. 2021;750: 1-15.

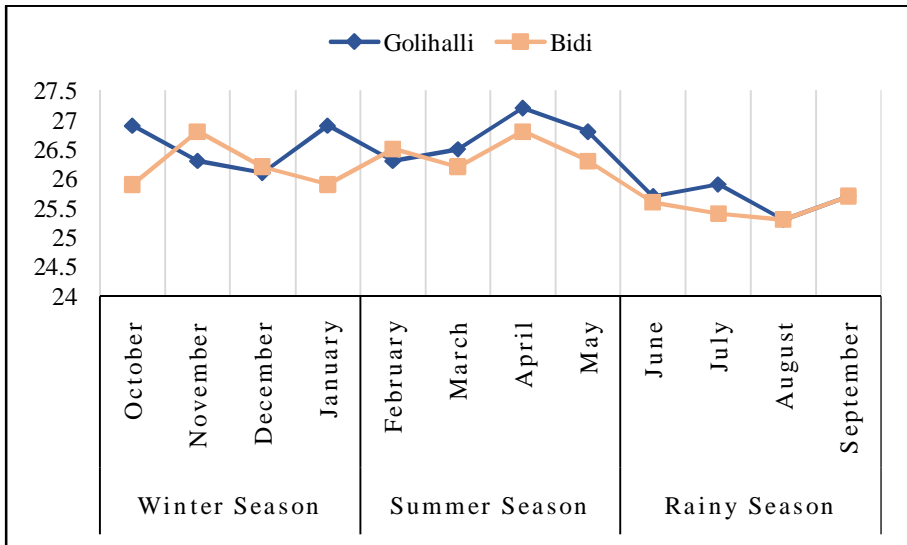
**Table-1: Monthly mean variation of selected parameters at Belagavi district**

		Selected Parameters											
		Temperature °C		Relative Humidity %		Carbon dioxide (CO <sub>2</sub> ) ppm		Carbon monoxide (CO) ppm		Particulate Matter (PM <sub>2.5</sub> ) µm <sup>3</sup>		Particulate Matter (PM <sub>10</sub> ) µm <sup>3</sup>	
Seasons	Months	V <sub>1</sub>	V <sub>2</sub>	V <sub>1</sub>	V <sub>2</sub>	V <sub>1</sub>	V <sub>2</sub>	V <sub>1</sub>	V <sub>2</sub>	V <sub>1</sub>	V <sub>2</sub>	V <sub>1</sub>	V <sub>2</sub>
Winter Season	October	26.9	25.9	67	63.8	841	839	20	21	50	51	92	94
	November	26.3	26.8	60.3	64.3	878	887	24	25	53	55	95	97
	December	26.1	26.2	66.5	65.8	936	941	26	25	55	57	102	113
	January	26.9	25.9	65.9	65.4	953	965	26	27	64	63	104	109
Average		<b>26.6</b>	<b>26.2</b>	<b>64.9</b>	<b>64.8</b>	<b>902</b>	<b>908</b>	<b>24</b>	<b>24.5</b>	<b>55.5</b>	<b>56.5</b>	<b>98.3</b>	<b>103.3</b>
Summer Season	February	26.3	26.5	66.6	65.7	969	989	27	28	65	66	119	115
	March	26.5	26.2	79.6	78.8	967	1003	28	29	67	69	127	123
	April	27.2	26.8	81.8	82.3	1029	1039	34	34	78	76	138	135
	May	26.8	26.3	78.8	77.9	993	998	29	28	68	67	122	124
Average		<b>26.7</b>	<b>26.5</b>	<b>76.7</b>	<b>76.1</b>	<b>989.5</b>	<b>1007.3</b>	<b>29.5</b>	<b>29.8</b>	<b>69.5</b>	<b>69.5</b>	<b>126.5</b>	<b>124.3</b>
Rainy Season	June	25.7	25.6	56.6	64.3	981	989	26	27	56	58	117	112
	July	25.9	25.4	44.4	56.6	882	872	24	24	49	46	96	97
	August	25.3	25.3	52.5	48.4	874	859	23	22	47	44	91	93
	September	25.7	25.7	41.7	42.3	789	778	21	20	41	43	87	84
Average		<b>25.7</b>	<b>25.5</b>	<b>48.8</b>	<b>52.9</b>	<b>881.5</b>	<b>874.5</b>	<b>23.5</b>	<b>23.3</b>	<b>48.3</b>	<b>47.8</b>	<b>97.8</b>	<b>96.5</b>
<b>Annual</b>		<b>26.3</b>	<b>26.1</b>	<b>63.5</b>	<b>64.6</b>	<b>924.3</b>	<b>929.9</b>	<b>25.7</b>	<b>25.8</b>	<b>57.8</b>	<b>57.9</b>	<b>107.5</b>	<b>108</b>

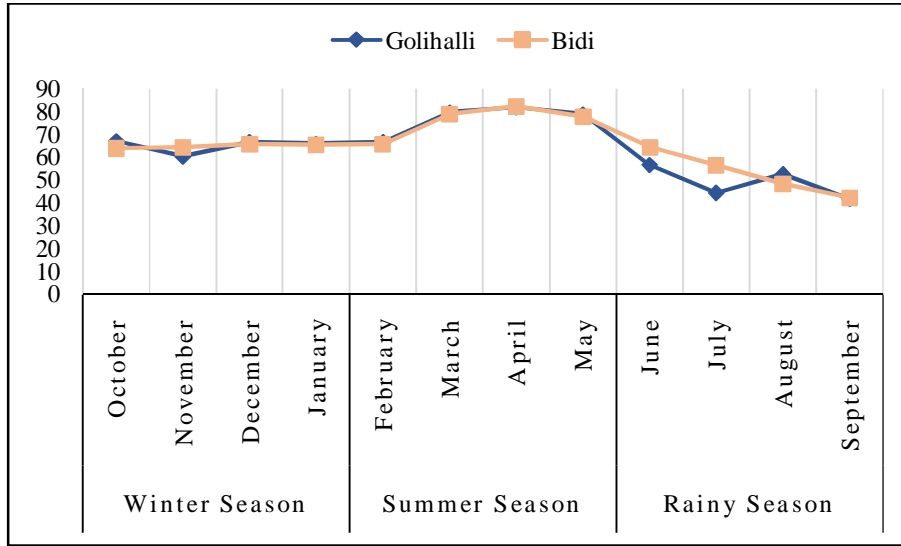
V<sub>1</sub>: Golihalli village, V<sub>2</sub>: Bidi village



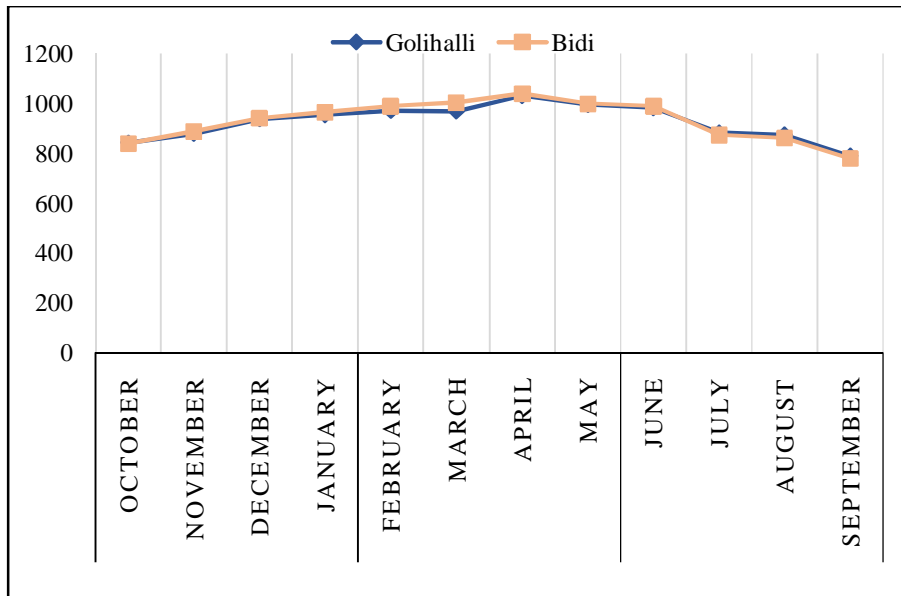
**Fig-5: Annual mean concentration of carbon emission**



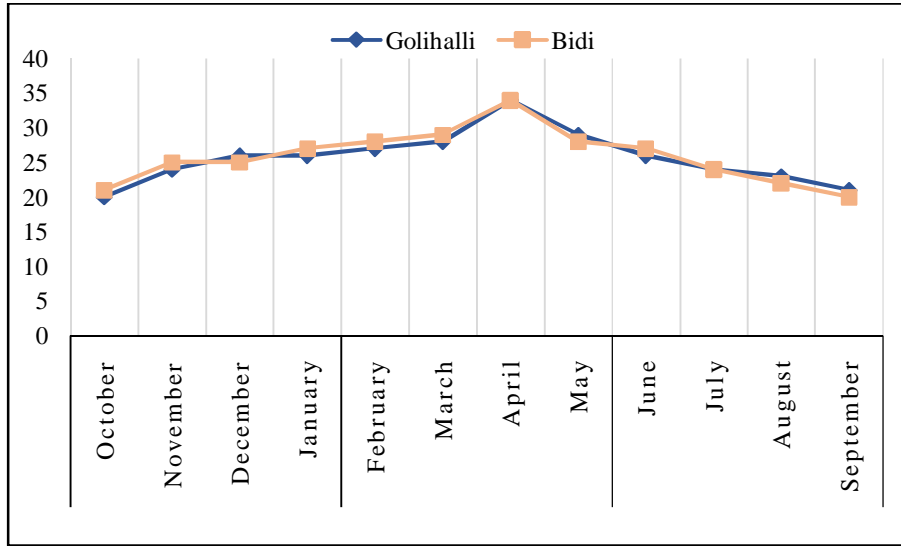
**Fig-6(a): Monthly mean variation of temperature**



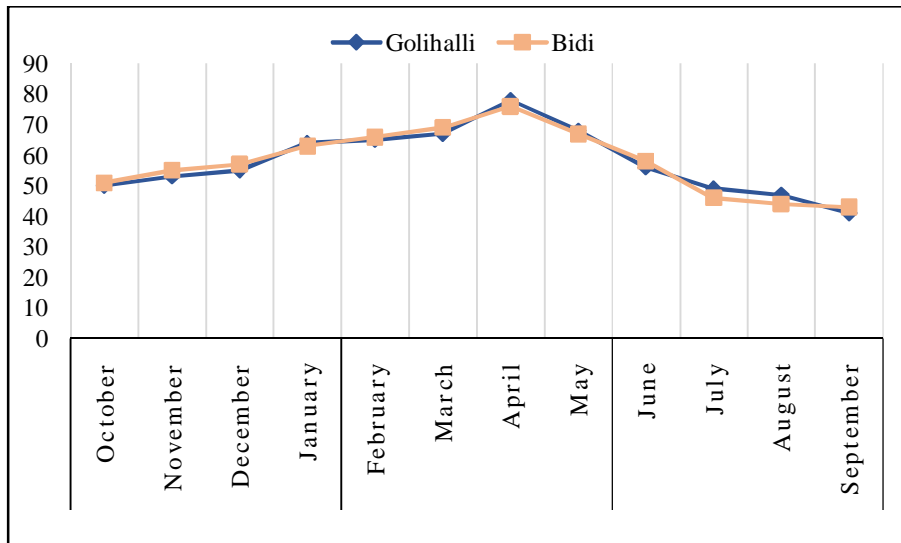
**Fig-6(b): Monthly mean variation of relative humidity**



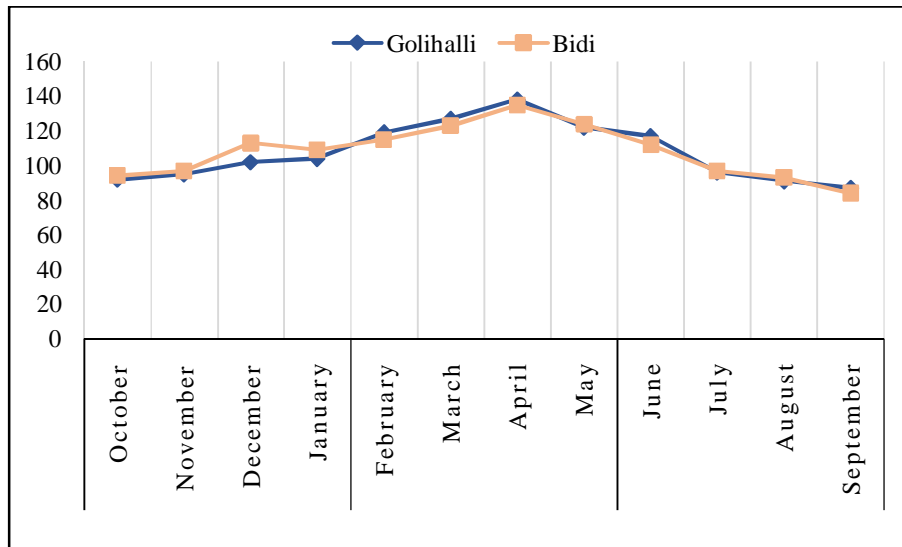
**Fig-6(c): Monthly mean variation of carbon dioxide (CO<sub>2</sub>)**



**Fig-6(d): Monthly mean variation of carbon monoxide (CO)**



**Fig-6(e): Monthly mean variation of particulate matter (PM<sub>2.5</sub>)**



**Fig-6(f): Monthly mean variation of particulate matter (PM<sub>10</sub>)**

**Table-2: One-Way ANOVA test for selected parameters based on seasons**

Parameters	Source of Variation	Sum of Squares	Degree of Freedom	Mean Squares	F-value	P-value
Temperature	Between Seasons	1.12	2	0.56	14*	0.03
	Within Seasons	0.12	3	0.04		
	Total	1.24	5			
Relative Humidity	Between Seasons	654.8	2	327.4	114.34**	0.001
	Within Seasons	8.59	3	2.86		
	Total	663.39	5			
Carbon dioxide (CO <sub>2</sub> )	Between Seasons	15965.81	2	7982.91	119.19**	0.001
	Within Seasons	200.92	3	66.97		
	Total	16166.73	5			
Carbon monoxide (CO)	Between Seasons	45.96	2	22.98	362.87**	0.0003
	Within Seasons	0.19	3	0.063		
	Total	46.15	5			
Particulate Matter (PM <sub>2.5</sub> )	Between Seasons	470.37	2	235.19	1128.89**	5E-05
	Within Seasons	0.63	3	0.208		

	Total	471	5			
Particulate Matter (PM <sub>10</sub> )	Between Seasons	944.36	2	472.2	89.85**	0.0021
	Within Seasons	15.77	3	5.26		
	Total	960.13	5			

\* Significant at P<0.05

\*\* Significant at P<0.01

**Table-3: Carbon sequestration of tree species in Golihalli and Bidi village of Belagavi district**

Sl. No.	Tree species (Common name)	Number of trees		Average age (year)		Average Tree Height (m)		Average DBH (m)		Total Biomass (Kg)		Carbon Storage (gm)		Carbon Sequestration (gm)	
		V <sub>1</sub>	V <sub>2</sub>	V <sub>1</sub>	V <sub>2</sub>	V <sub>1</sub>	V <sub>2</sub>	V <sub>1</sub>	V <sub>2</sub>	V <sub>1</sub>	V <sub>2</sub>	V <sub>1</sub>	V <sub>2</sub>	V <sub>1</sub>	V <sub>2</sub>
1	<i>Anacardium occidentale</i> (Cashew)	2	1	11.9	10.7	4.6	4.9	0.15	0.13	0.006	0.005	2.95	2.6	10.81	9.52
2	<i>Artocarpus heterophyllus</i> (Jack fruit)	2	1	11.6	12.2	4.9	5.2	0.14	0.15	0.006	0.007	3.12	3.42	11.4	12.53
3	<i>Azdirachta indica</i> (Neem)	8	7	50	47.7	15.8	16.1	0.53	0.51	0.28	0.271	142.01	135.36	519.77	495.4
4	<i>Cocos nucifera</i> (Coconut)	8	8	27.1	26.7	17.1	17	0.3	0.3	0.1	0.092	49.29	45.87	180.39	167.89
5	<i>Couroupita guianensis</i> (Cannonball tree)	1	-	25.4	-	10.9	-	0.28	-	0.051	-	25.91	-	94.83	-
6	<i>Ficus benhalensis</i> (Banyan)	4	3	11.8	10.7	21.7	19.4	0.15	0.13	0.027	0.021	13.66	10.64	49.99	38.94
7	<i>Ficus carica</i> (Fig)	3	2	26.1	22.7	11	11	0.29	0.26	0.055	0.043	27.68	21.38	101.29	78.23
8	<i>Magnolia champaca</i> (Champak)	2	1	10.2	11.3	7.7	7.8	0.13	0.14	0.008	0.009	3.8	4.53	13.92	16.6
9	<i>Mangifera indica</i> (Mango)	3	3	11.6	10.2	15.5	14.6	0.14	0.13	0.019	0.015	9.29	7.52	34.01	27.53
10	<i>Millettia pinnata</i> (Indian beech)	2	1	17.6	15.1	12.7	11.3	0.2	0.18	0.033	0.021	16.74	10.67	61.27	39.05
11	<i>Moringa oleifera</i> (Drumstick)	2	2	9.6	7.7	5.8	5.5	0.12	0.1	0.005	0.004	2.65	1.81	9.68	6.64
12	<i>Murraya koenigii</i> (Curry)	2	2	4.9	5.7	3.7	3.9	0.08	0.08	0.001	0.002	0.6	0.8	2.19	2.93
13	<i>Phyllanthus emblica</i>	3	2	9.3	10.8	5.6	6	0.12	0.14	0.005	0.007	2.41	3.28	8.82	12.01

	(Indian gooseberry)														
14	<i>Saraca asoca</i> (Ashoka)	3	1	23.1	20.4	7.4	6.4	0.26	0.23	0.031	0.021	15.73	10.28	57.57	37.63
15	<i>Syzygium cumini</i> (Java plum)	3	2	20.8	21	11	11	0.24	0.24	0.038	0.036	18.9	18.08	69.16	66.17
16	<i>Tamarindus indica</i> (Tamarind)	6	6	42.3	47.8	17.7	17.6	0.46	0.51	0.24	0.29	119.75	144.87	438.27	530.22
17	<i>Tectona grandis</i> (Teak)	3	2	7.1	7.1	7.9	8.5	0.1	0.1	0.005	0.005	2.25	2.52	8.25	9.23
	<b>Total</b>	<b>57</b>	<b>44</b>	<b>320.4</b>	<b>287.8</b>	<b>181</b>	<b>166.2</b>	<b>3.69</b>	<b>3.33</b>	<b>0.91</b>	<b>0.849</b>	<b>456.74</b>	<b>423.63</b>	<b>1671.62</b>	<b>1550.52</b>

V<sub>1</sub>: Golihalli village, V<sub>2</sub>: Bidi village

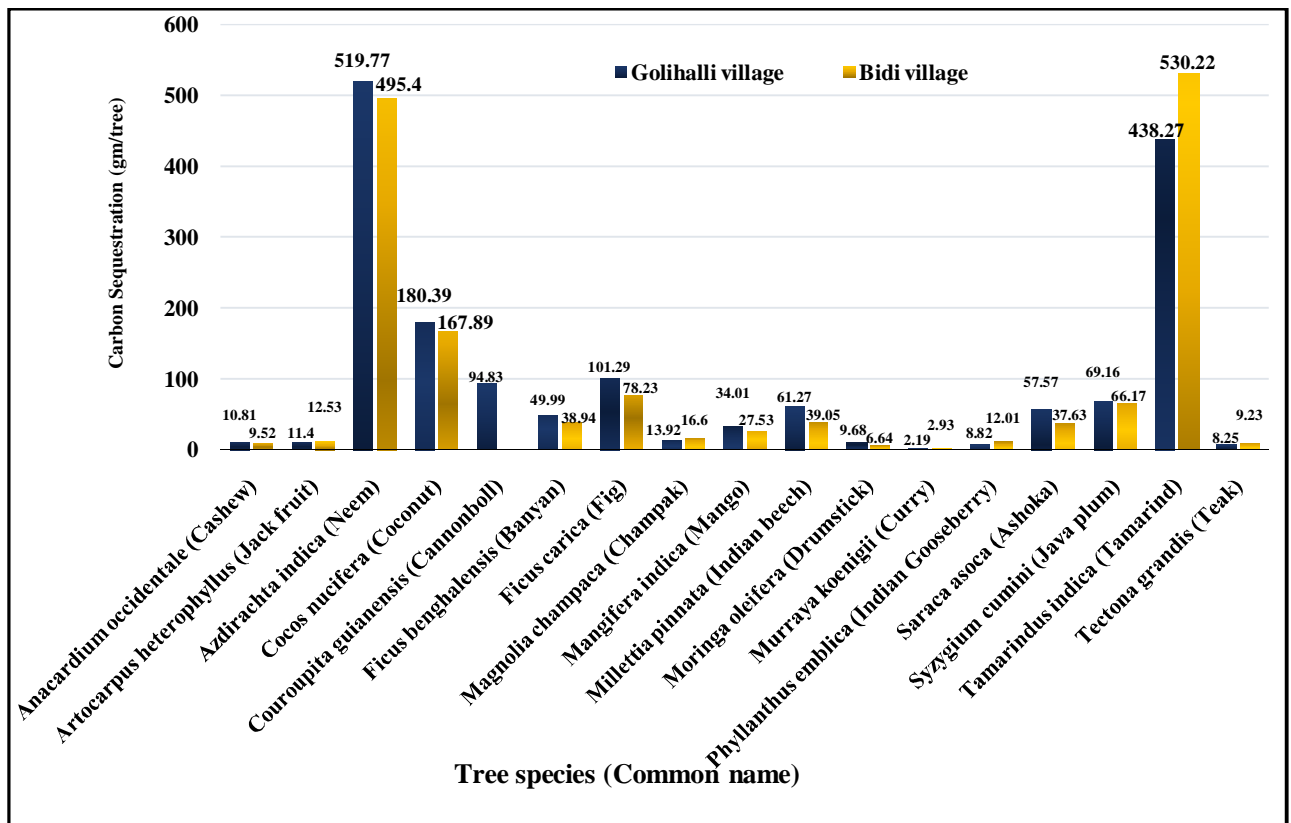
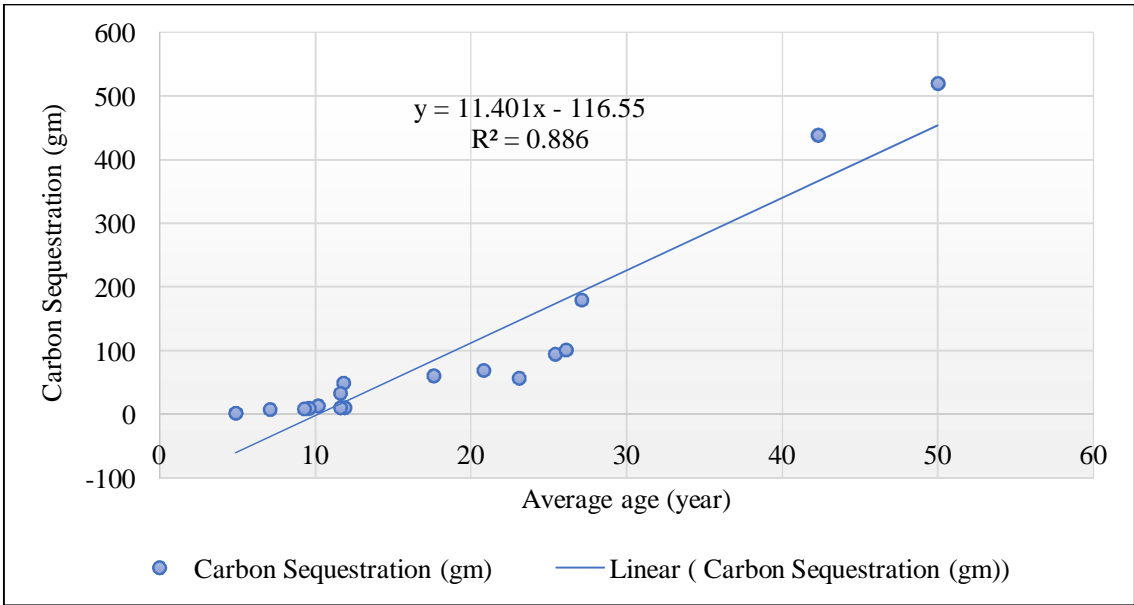
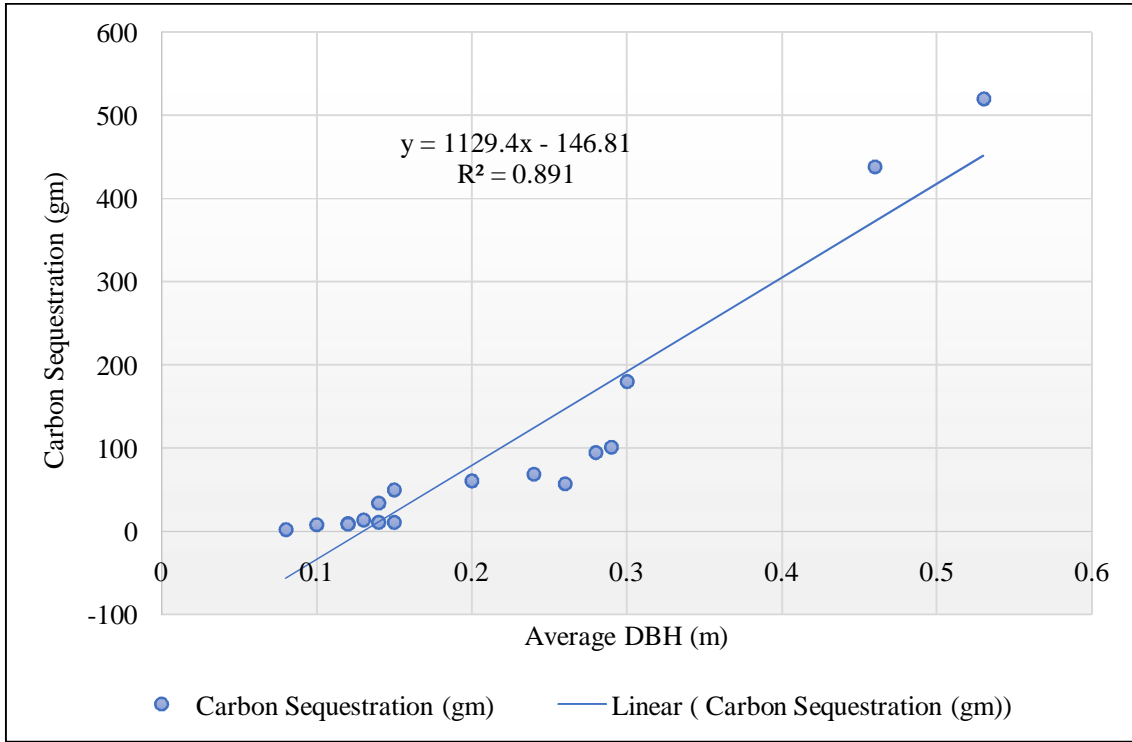


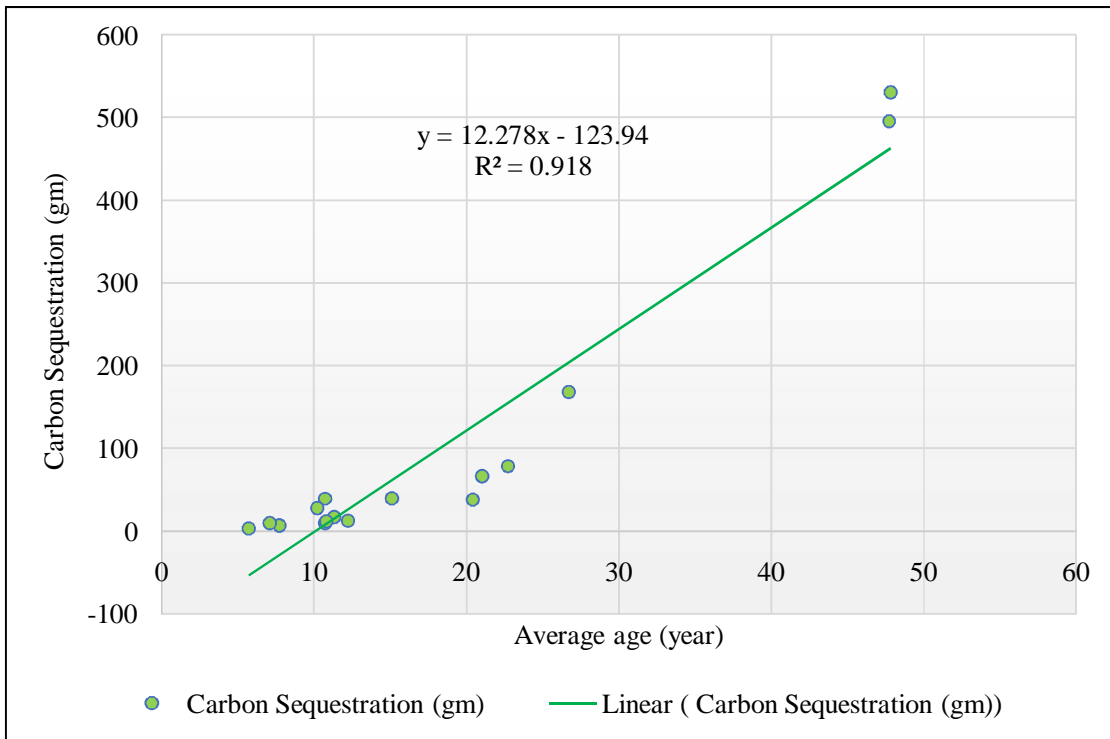
Fig-7: Graphical representation of carbon sequestration of tree species



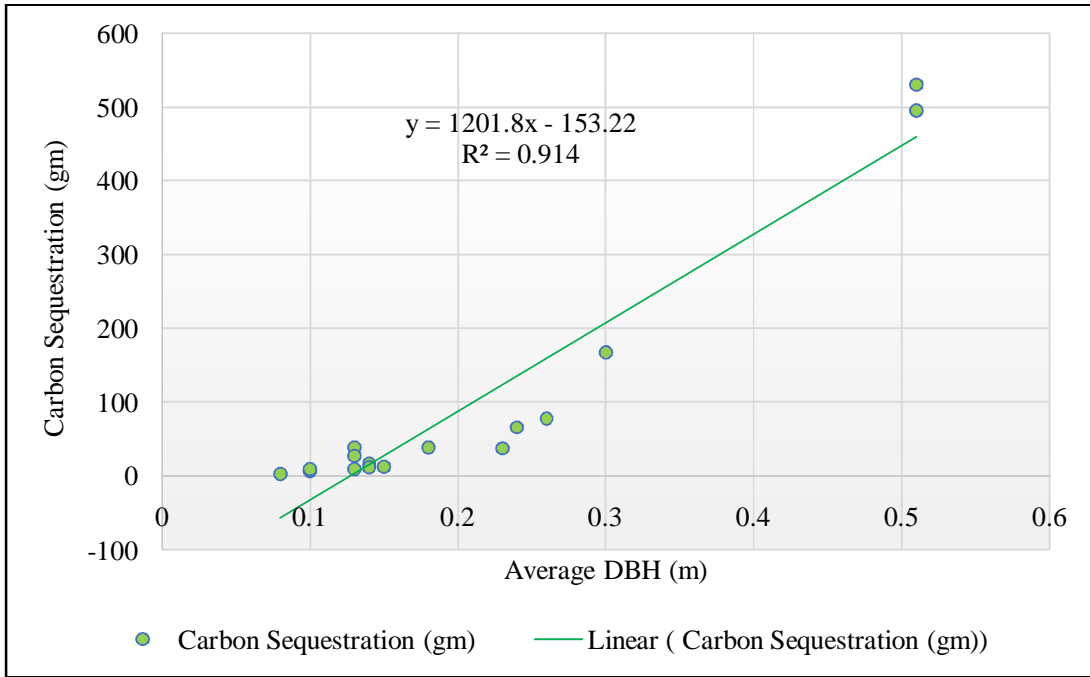
**Fig-8 (a): Relationship between average age of trees and carbon sequestration in Golihalli village**



**Fig-8 (b): Relationship between average DBH of trees and carbon sequestration in Golihalli village**



**Fig-8 (c): Relationship between average age of trees and carbon sequestration in Bidi village**



**Fig-8 (d): Relationship between average DBH of trees and carbon sequestration in Bidi village**

**Table-4: Pearson Correlation analysis reflecting the relationship between different parameters of trees**

Villages		Average Age	Average DBH	Total Biomass	Carbon Storage	Carbon Sequestration
Golihalli village	Average Age	1				
	Average DBH	1**	1			
	Total Biomass	0.94**	0.94**	1		
	Carbon Storage	0.94**	0.94**	1**	1	
	Carbon Sequestration	0.94**	0.94**	1**	1**	1
		Average age	Average DBH	Total Biomass	Carbon Storage	Carbon Sequestration
Bidi village	Average Age	1				
	Average DBH	1**	1			
	Total Biomass	0.97**	0.96**	1		
	Carbon Storage	0.97**	0.96**	1**	1	
	Carbon Sequestration	0.97**	0.96**	1**	1**	1

\*\* Significant at  $P < 0.01$