Universal Journal of Environmental Research and Technology
 eISSN 2249 0256
Available Online at: www.environmentaljournal.org
Volume 2, Issue 1: 85-92

Open Access **Research Article**

Comparative Status of Carbon Dioxide Sequestration in *Albizia Lebbek* and *Delonix Regia*

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Abstract:

Biomass production in different forms plays important role in carbon sequestration in trees. In the present investigation aboveground and belowground carbon sequestration potential of *Albizia lebbeik* from nine sectors of Aurangabad city was measured. The standing aboveground biomass and belowground biomass of *Albizia lebbek* were 53.73 tha^{-1} and 13.97 tha^{-1} respectively, while total standing biomass of *Albizia lebbek* in 2847 hectares area was 67.70 tha^{-1}. The standing aboveground biomass and belowground biomass of *Delonix regia* were 30.25tha^{-1} and 07.86tha^{-1} respectively, while total standing biomass of *Delonix regia* in 2847 hectares area was 38.11tha^{-1}. The average carbon sequestration and carbon dioxide of *Albizia lebbek* intake is 33.85tha^{-1} and 124.23 tCO_2 in Aurangabad. The average carbon sequestration and carbon dioxide of *Delonix regia* intake is 19.06$tCha^{-1}$ and 63.96 tCO_2 in Aurangabad. The highest sequestered carbon dioxide percentage in *Albizia lebbek* at sector 7th it is 20% and lowest at sector 1st it is 1%, while, in *Delonix regia* the highest in sector 7th (20%) and lowest in sector 1st (2%).

Keywords: Aboveground carbon, *Albizia lebbek*, belowground carbon, carbon stock, carbon sequestration potential, climate change.

1.0 Introduction:

As more photosynthesis occurs, more CO_2 is converted into biomass, reducing carbon in the atmosphere and sequestering it in plant tissue above and below ground (Gorte, 2009; IPCC, 2003) resulting in growth of different parts (Chavan and Rasal, 2010). In the global carbon cycle biomass is an important building block, significally carbon sequestration and is used to help quantify pools and changes of Green House Gases from the terrestrial biosphere to the atmosphere associated with land-use and land cover changes (Cairns et al., 2003; IPCC, 2001). Above-ground biomass, below-ground biomass, dead wood, litter, and soil organic matter are the major carbon pools in any ecosystem (FAO, 2005; IPCC, 2003; IPCC, 2006). The increasing carbon emission is of major concerns for entire world as well addressed in Kyoto protocol (Chavan, and Rasal, 2010; Ravindranath, et. al., 1997). Carbon sequestration in growing forests is known to be a cost-effective option for mitigation of global warming and global climatic change. In terms of atmospheric carbon reduction, trees in urban areas offer the double benefit of direct carbon storage and maintenance of climatic conditions by its bio-geo-chemical processes (Chavan, and Rasal, 2010). India is sequestrating more than 116 million tones of CO_2 per year which is equal to 32 millions of carbon sequestration, contributes to reduce atmospheric carbon of the globe (SFR, 2009; Jasmin and Birundha, 2011). Estimates of carbon stocks and stock changes in tree biomass (above and belowground) are necessary for reporting to the United Nations Framework Convention on Climate Change (UNFCCC) and will be required for Kyoto Protocol reporting (Green et al. 2007; Almgir and Al-Amin, 2007). The objective of this paper is to study of comparative status of carbon sequestration in *Albizia lebbek* and *Delonix regia.*

2.0 Experimental Methodology:

2.1 Study Area:

The study is located in the state of Maharashtra, in India. Aurangabad is located at the latitude $19^0$53'47"N and longitude $75^0$23'54" E. The average day temperature ranges from 27.7^0C to 38.0^0 C while it falls from 26.9^0C to 20.0^0C during night. The average annual rainfall in Aurangabad city and adjoining area is 725.8 mm (28.57''). Relative humidity is extremely low in this region for major part of the year which ranges between 35 to 50%, while it is highest (85%) during monsoon (ESRAM,

2009; 2010). The total land portion under forest cover is about 557 km^2 which is only 7.6% area of total land area in Aurangabad (SFR, 2009). The total 28.47 sq.km area of Aurangabad city is selected for the carbon sequestration study.

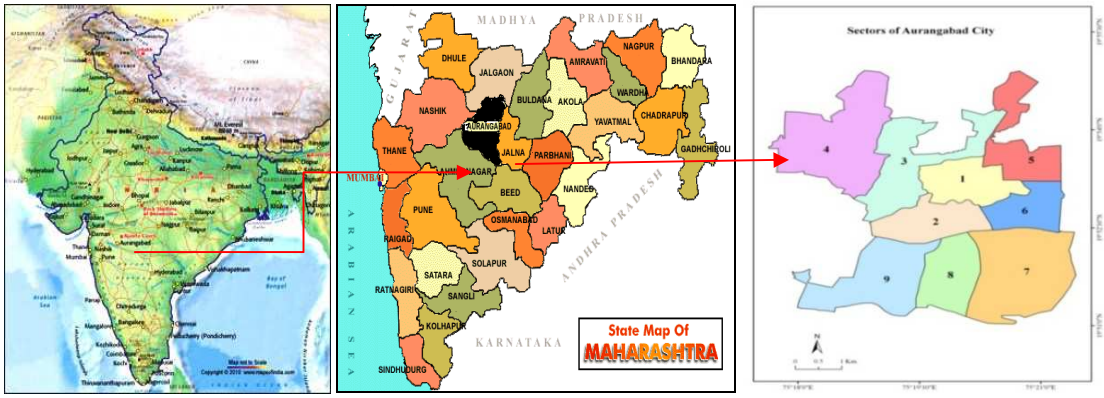

Figure 1: Map indicates the location of study area.
(http://www.mapsofIndia.com, Source: http://bhuvan-noeda.nrsc.gov.in)

2.2 Description of Sampling Sites:

The total 2847 hectares of study area from Aurangabad was selected for the carbon sequestration studies. The fig.1 shows the Aurangabad city are divided into 9 sectors from which the sampling was carried out. Each colour indicates separate sector for the present study constituting it as sampling location for *Albizia lebbek* and *Delonix regia* trees.

Sector 1: The 1st sector is comprised of 221 hectare of area. It included the areas like Aurangpura, Shahaganj, New mondha, Harsh nagar, Aurangabad municipal corporation, Lotakaranja, City police chowk, Sarafa road and Ginning factory and surrounding area. The vegetation here pre-dominantly is comprised of *Polyalthia longifolia*, *Acacia nilotica*, Badam, *Mangifera indica, Azadirachata indica,* etc.

Sector 2: The 2nd sector is comprised of 223 hectares of area which included the areas like Samarth nagar, nirala bazaar, kranti chowk, mondha naka and surrounding area with heavy traffic areas. The *Polyalthia longifolia*, *Azadirachata indica*, *Mangifera indica,* Nilgiri are dominant tree species in this sector.

Sector 3: The 3rd sector is comprised of 356 hectares of area which included the areas like Begumpura, Government College, Lake, zilla parishad quarters, collector office, Bus stand, Bibi-ka Maqbara, Panchakki, Salim Ali lake, Delhi gate, Dr. B.A. research center and surrounding area. The *Polyalthia longifolia*, *Delonix regia, Azadirachata indica*, *Cassia siamea,* Badam are dominant tree species in this sector.

Sector 4: The 4th sector is comprised of 528 hectares of areas which included the areas like Jaisingpura, Dr. B.A.M. University, Aurangabad, Pahadsingpura, and its surrounding areas. The university campus is having very reach biodiversity and number of trees. The major plantation of *Mangifera indica, Annona reticulata, Annona squamosa, Emlica officinalis,* and *Peltaphorum pterocarpum, Azadirachata indica* are dominant species in this sector.

Sector 5: The 5th sector is comprised of 244 hectares of areas which included the area like Commissioner Office, Maulana Azad research center, IPS office, Police public school, TV center, Jasawantpura, and surrounding area. It is comparative silent area and dense vegetation observed near as government offices. The *Polyalthia longifolia*, *Azadirachata indica, Cassia siamea, Delonix regia* are dominant tree species present in this area.

Sector 6: The 6th sector is comprised of 175 hectares of areas which included the areas like CIDCO, Baijipura, Cannaught garden, MGM-JNEC colleges, N-6, N-7, Jincy, Mondha, Jalna road, etc and its surrounding area. Jalna road is heavy traffic area while, MGM and JNEC college with dense vegetation. The *Polyalthia longifolia*, *Azadirachata indica*, *Tarminalia cattappa*, *Sesbania sesban* are dominant tree species present in this sector.

Sector 7: The 7th sector is comprised of 501 hectares. It include areas like as Shivchchatrapati college, Kamgar chowk, hedgewar hospital, shivajinagar area, and surrounding area. The *Polyalthia longifolia*,

Azadirachata indica, *Eucalyptus citridora, Milingtonia hortensis* are dominant tree species present in this sector.

Sector 8: The 8th sector is comprised of 232 hectares of areas which includes Garkheda, Shahanurmiya darga, Osmanpura, Jawahar colony area and surrounding areas. The *Polyalthia longifolia*, *Azadirachata indica*, *Eucalyptus citridora* are dominant tree species present in this sector.

Sector 9: The 9th sector is comprised of 369 hectares of areas. It includes areas like as Baba petrol pump, Railway station, Devgiri college, Bansilal nagar, Forest office, Beed bypass and surrounding areas. The *Polyalthia longifolia*, *Azadirachata indica*, *Roystonea regia*, *Albizia lebbeck* are dominant tree species present in this sector.

2.3 Description of Species Studied:

Fig. 2a: *Albizia lebbek*

Fig. 2b: *Delonix regia*

Albizia lebbek is a species of genus *Albizia*. It is native to tropical southern part of Asia. It is widely cultivated and naturalized in other tropical and subtropical regions. *Albizia lebbek* is one of the most widely spread and common species of *Aibizia* and hence finds worldwide. *A. lebbek* is a dominant and common species in semi-evergreen monsoon forests in areas where the mean annual rainfall is 1300-1500 mm and climate is very dry-winter (www.worldagroforestry.org).

Delonix regia is a species of flowering plant from the Fabaceae family, Caesalpinioideae subfamilia. *Delonix regia* is endemic to the western forests of Madagascar, but has been introduced into tropical and sub-tropical regions worldwide. It is grown as an ornamental tree in many tropical countries and almost all around the world. Trees of *Delonix regia* grow better at higher altitudes, but flowering becomes erratic. It is famously known and noted for its fern-like leaves and flamboyant display of flowers. The tree of *Delonix regia* demands for its healthy growth and grows weakly and sparingly under shade. It can grow in the areas with high and insufficient rainfall (www.worldagroforestry.org).

2.3.1 Biophysical Measurements:

The height and diameter at breast height (DBH) are two main biophysical measurements which measured for each tree sample. The height of *Albizia lebbek* (fig.2a) and *Delonix regia* (fig.2b) tree were measured by Theodolite instrument follower the procedure given elsewhere (Chavan and Rasal, 2009; 2010; 2011a). The tree diameter was measured at breast height (DBH) by using diameter measure tape.

2.3.2 Estimation of Aboveground Biomass:

Above-ground biomass includes all living biomass above the soil. The aboveground biomass (AGB) has been calculated by multiplying volume of biomass and wood density (Brown, 1997; Ravindranath and Ostwald, 2008; Chavan and Rasal, 2011b; 2012b). The volume was calculated based on diameter and height. The wood density value for the *Albizia lebbek* and *Delonix regia* species obtained from web (www.worldagroforestry.org).

AGB (g) = Volume of biomass (cm3) X wood density (g/cm3)

The biomass of all samples *Albizia lebbek* and *Delonix regia* trees in the all the sample plots (t) was calculated and extrapolating it for total area for tons per hectare (tha^{-1}).

2.3.3 Estimation of Belowground Biomass:

The Below Ground Biomass (BGB) includes all biomass includes all biomass of live roots excluding fine roots having <2mm diameter (Chavan and Rasal, 2011; 2012a; 2012b). Biomass estimation equations for tree roots are relatively uncommon in the literature. The belowground biomass (BGB) has been calculated by multiplying above-ground biomass taking 0.26 as the root to shoot ratio (Cairns et al. 1997; Ravindranath and Ostwald, 2008).

Belowground biomass (tha^{-1}) = 0.26 X above-ground biomass (tha^{-1})

3.0 Result and Discussion:

3.1 Biomass estimation:

The estimation of the aboveground and belowground biomass in the selected tree species was performed by estimating carbon percentage and by measuring the tree height, DBH and wood density. The carbon concentration of different tree parts was rarely measured directly, but generally assumed to be 50% of the dry weight on the basis of literature (Chavan and Rasal, 2011; 2012b; Jana et al., 2009) as the content of carbon in woody biomass in any component of forest on average is around 50% of dry matter (Paladinic et al., 2009; Chavan and Rasal, 2011; 2012a; 2012b).

The standing biomass stalks in *Albizia lebbek* trees in Aurangabad are shown in Table 1. It was observed that in sector no. 5 the *Albizia lebbek* tree containing highest aboveground biomass, belowground biomass and total standing biomass (9.98 tha^{-1}, 2.60 tha^{-1} and 12.58 tha^{-1}) followed in sector no. 9 (9.47tha^{-1}, 2.46 tha^{-1} and 11.94 tha^{-1}), in sector no. 6 and 7 (7.93 tha^{-1}, 2.06 tha^{-1} and 9.99 tha^{-1} each), sector no. 4 (6.05 tha^{-1}, 1.57 tha^{-1} and 7.62 tha^{-1}), sector no. 3 (5.65 tha^{-1}, 1.47 tha^{-1} and 7.11 tha^{-1}), sector no. 2 (2.69 tha^{-1}, 0.70 tha^{-1} and 3.38 tha^{-1}), sector no. 8 (2.39 tha^{-1}, 0.62 tha^{1} and 3.01 tha^{-1}) and lowest at sector no. 1 (1.65 tha^{-1}, 0.43tha^{-1} and 2.08 tha^{-1}) respectively. The standing aboveground biomass and belowground biomass of *Albizia lebbek* were 53.73tha^{-1} and 13.97tha^{-1} respectively, while total standing biomass of *Albizia lebbek* in 2847 hectares area was 67.70tha^{-1}.

The sequestered carbon stalks in *Albizia lebbek* trees in Aurangabad are shown in Table 1. It was observed that in sector no. 5 the *Albizia lebbek* tree containing highest carbon stalk in aboveground, belowground and total carbon sequestered (4.99 tha^{-1}, 1.30 tha^{-1} and 6.29 tha^{-1}) followed in sector no. 9 (4.74 tha^{-1}, 1.23 tha^{-1} and 5.97 tha^{-1}), in sector no. 6 and 7 having same amount of sequestered carbon (0.76 tha^{-1}, 0.19 tha^{-1} and 0.95 tha^{-1} each), sector no. 4 (3.02 tha^{-1}, 0.79 tha^{-1} and 3.81 tha^{-1}), sector no. 3 (2.82 tha^{-1}, 0.73 tha^{-1} and 3.56 tha^{-1}), sector no. 2 (1.34 tha^{-1}, 0.35 tha^{-1} and 1.69 tha^{-1}), sector no. 8 (1.19 tha^{-1}, 0.31 tha^{1} and 1.51 tha^{-1}) and lowest at sector no. 1 (0.82 tha^{-1}, 0.21 tha^{-1} and 1.04 tha^{-1}) respectively. The sequestered carbon stalk in aboveground and belowground standing biomass of *Albizia lebbek* were 26.87tha^{-1} and 6.99 tha^{-1} respectively, while total sequestered carbon of *Albizia lebbek* in 2847 hectares area was 33.85 tha^{-1}. The average carbon sequestration and carbon dioxide of *Albizia lebbek* intake is 33.85tha^{-1} and 124.23 tCO_2 in Aurangabad city. Total aboveground biomass carbon per hectare for *A. lebbek* was 6.26 tCha-1 estimated by (Jana, 2009). The total aboveground biomass carbon stock per hectare as estimated for *Shorea robusta*, *Albizzia lebbek*, *Tectona grandis* and *Artocarpus integrifolia* were 5.22$tCha^{-1}$, 6.26 $tCha^{-1}$, 7.97 $tCha^{-1}$ and 7.28 $tCha^{-1}$ respectively in selected forest stands (Jana, et al., 2009).

From the fig.3 it is revealed that cumulative percentage of carbon dioxide intake (tCO_2) in *Albizia lebbek* in nine sectors of Aurangabad city the highest sequestered carbon dioxide in sector 5^{th} (19%) followed by sector 9^{th} (18%), sector 6^{th} & 7^{th} (15% each), sector 4^{th} (11%), sector 5^{th} (10%), in sectors 2^{nd} (5%), in sectors 8^{th} (4%) and lowest in sector 1^{st} (3%). The total aboveground biomass carbon stock per hectare as estimated for *Shorea robusta*, *Albizzia lebbek*, *Tectona grandis* and *Artocarpus integrifolia* were 5.22$tCha^{-1}$, 6.26$tCha^{-1}$, 7.97$tCha^{-1}$ and 7.28$tCha^{-1}$ respectively in selected forest stands (Jana, et al., 2009).

Table 1: The sector wise total biomass and sequestered carbon of *Albizia lebbek* in Aurangabad

Sectors	Area in ha	Tree count	AGB tha^{-1}	BGB tha^{-1}	TGB tha^{-1}	AGC tha^{-1}	BGC tha^{-1}	TC tha^{-1}	tCO_2
1	221	78	1.65	0.43	2.08	0.82	0.21	1.04	3.81
2	223	127	2.69	0.70	3.38	1.34	0.35	1.69	6.20
3	356	267	5.65	1.47	7.11	2.82	0.73	3.56	13.06
4	528	286	6.05	1.57	7.62	3.02	0.79	3.81	14
5	244	472	9.98	2.60	12.58	4.99	1.30	6.29	23.08
6	175	375	7.93	2.06	9.99	3.96	1.03	5.00	18.35
7	501	375	7.93	2.06	9.99	3.96	1.03	5.00	18.35
8	232	113	2.39	0.62	3.01	1.19	0.31	1.51	5.54
9	369	448	9.47	2.46	11.94	4.74	1.23	5.97	21.9
Total	2847	2541	53.73	13.97	67.70	26.87	6.99	33.85	124.2

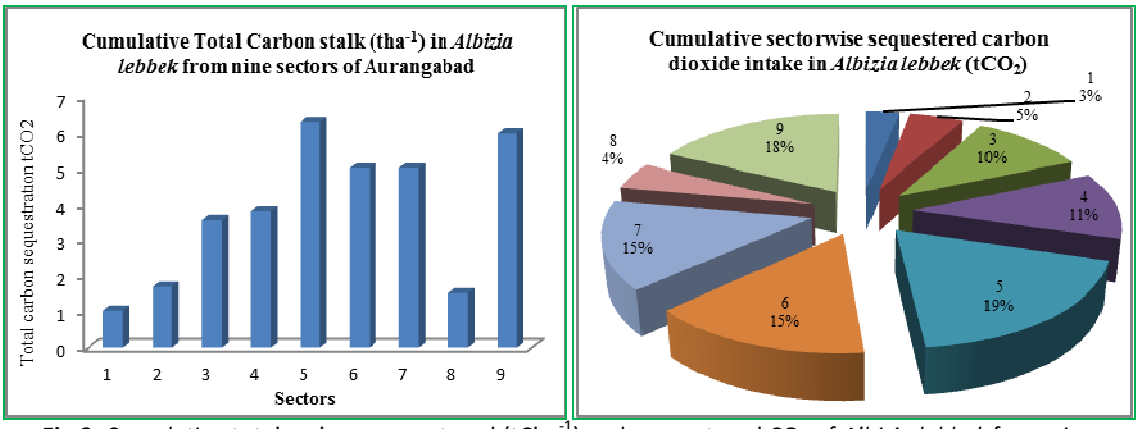

Fig.3: Cumulative total carbon sequestered ($tCha^{-1}$) and sequestered CO_2 of *Albizia lebbek* from nine Sectors of Aurangabad city

Table 2: The sector wise total biomass and sequestered carbon of *Delonix regia* in Aurangabad

Sectors	Area in ha	Tree count	AGB. tha^{-1}	BGB tha^{-1}	TGB t tha^{-1}	AGC tha^{-1}	BGC tha^{-1}	TC tha^{-1}	tCO_2
1	221	118	0.72	0.19	0.91	0.36	0.09	0.45	1.65
2	223	327	2.00	0.52	2.51	1.00	0.26	1.26	4.62
3	356	479	2.92	0.76	3.68	1.46	0.38	1.84	6.75
4	528	376	2.29	0.60	2.89	1.15	0.30	1.45	5.32
5	244	635	3.87	1.01	4.88	1.94	0.50	2.44	8.95
6	175	948	5.79	1.50	7.29	2.89	0.75	3.64	13.36
7	501	987	6.02	1.57	7.59	3.01	0.78	3.79	13.9
8	232	373	2.28	0.59	2.87	1.14	0.30	1.43	5.25
9	369	714	4.36	1.13	5.49	2.18	0.57	2.74	10
Total	2847	4957	30.25	7.86	38.11	15.12	3.93	19.06	69.95

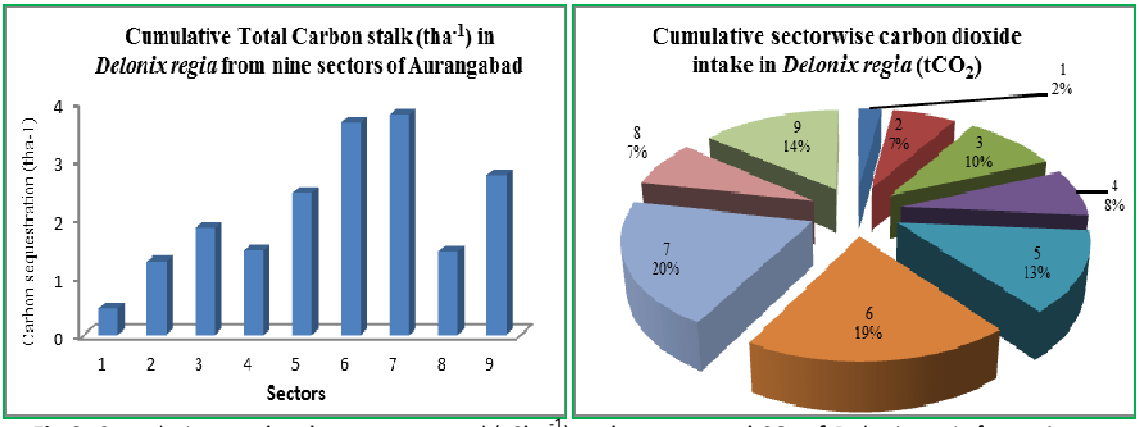

Fig.3: Cumulative total carbon sequestered ($tCha^{-1}$) and sequestered CO_2 of *Delonix regia* from nine sectors of Aurangabad.

The standing biomass stalks in *Delonix regia* trees in Aurangabad are shown in Table 2. It was observed that in sector no. 7 the *Delonix regia* tree containing highest aboveground biomass, belowground biomass and total standing biomass (6.02 tha^{-1}, 1.57 tha^{-1} and 7.59 tha^{-1}) followed in sector no. 6 (5.29tha^{-1}, 1.50 tha^{-1} and 7.29 tha^{-1}), sector no. 9 (4.36 tha^{-1}, 1.13 tha^{-1} and 5.49 tha^{-1}), sector no. 5 (3.87 tha^{-1}, 1.01 tha^{-1} and 4.88 tha^{-1}), sector no. 3 (2.92 tha^{-1}, 0.76 tha^{-1} and 3.68 tha^{-1}), sector no. 4 (2.29 tha^{-1}, 0.60 tha^{-1} and 2.89 tha^{-1}), sector no. 8 (2.28 tha^{-1}, 0.59 tha^{1} and 2.87 tha^{-1}), sector no. 2 (2.0 tha^{-1}, 0.52 tha^{-1} and 2.51 tha^{-1}) and lowest at sector no. 1 (0.72 tha^{-1}, 0.19 tha^{-1} and 0.91 tha^{-1}) respectively. The standing aboveground biomass and belowground biomass of *Delonix regia* were 30.25tha^{-1} and 07.86tha^{-1} respectively, while total standing biomass of *Delonix regia* in 2847 hectares area was 38.11tha^{-1}.

The sequestered carbon stalks in *Delonix regia* trees in Aurangabad are shown in Table 2. It was observed that in sector no. 7 the *Delonix regia* tree containing highest carbon stalk in aboveground, belowground and total carbon sequestered (3.01 tha^{-1}, 0.78 tha^{-1} and 3.79 tha^{-1}) followed in sector no. 6 (2.89 tha^{-1}, 0.75 tha^{-1} and 3.64 tha^{-1}), sector no. 9 (2.18 tha^{-1}, 0.57 tha^{-1} and 2.74 tha^{-1}), sector no. 5 (1.94 tha^{-1}, 0.50 tha^{-1} and 2.44 tha^{-1}), sector no. 3 (1.46 tha^{-1}, 0.38 tha^{-1} and 1.84 tha^{-1}), sector no. 4 (1.15 tha^{-1}, 0.30 tha^{-1} and 1.45 tha^{-1}), sector no. 8 (1.14tha^{-1}, 0.30tha^{1} and 1.43 tha^{-1}), sector no.2 (1.0tha^{-1}, 0.26 tha^{-1} and 1.26 tha^{-1}) and lowest at sector no. 1 (0.36 tha^{-1}, 0.09 tha^{-1} and 0.45 tha^{-1}) respectively. The sequestered carbon stalk in aboveground and belowground standing biomass of *Delonix regia* were 15.12 tha^{-1} and 3.93tha^{-1} respectively, while total standing biomass of *Delonix regia* in 2847 hectares area was 19.06$tCha^{-1}$. The average carbon sequestration and carbon dioxide of *Delonix regia* intake is 19.06$tCha^{-1}$ and 63.96 tCO_2 in Aurangabad. From the fig.3 it is revealed that cumulative percentage of carbon dioxide intake (tCO_2) in *Delonix regia* in nine sectors of Aurangabad city the highest sequestered carbon dioxide in sector 7th (20%) followed by sector 6th (19%), sector 9th (14%), sector 5th (13%), in sectors 3th (10%), in sectors 4nd (8%), sector 8th & 2th (7% each), and lowest in sector 1st (2%).

The carbon sequestration is multiplied by factor of 3.67 to get the carbon dioxide (CO_2) because 1 ton carbon is equal to 3.67 tones of CO_2 (Kumar et. al., 2009; Jasmin and Birundha, 2011; Jindal et al., 2007). The total of aboveground biomass and belowground biomass together as sequestered carbon stalk per hectare as estimated from university campus *Mangifera indica* it was 30.6 Kg C ha^{-1} (Chavan and Rasal, 2011a) and from Aurangabad city it was 56.36 $tCha^{-1}$ and atmospheric CO_2 intake was 206.84tCO_2 (Chavan and Rasal, 2012a). The average carbon sequestration and carbon dioxide of *Eucalyptus ssp.* intake is 320.67tha^{-1} and 1176.85 tCO_2 in 2847 hectares of area at Aurangabad city (Chavan and Rasal, 2011b).

4.0 Conclusion:

The total standing biomass *Albizia lebbek* was in 2847 hectares area was 67.70$tCha^{-1}$, while in *Delonix regia* in 2847 hectares area was 38.11$tCha^{-1}$. The cumulative carbon sequestration and carbon dioxide of *Albizia lebbek* intake is 33.85$tCha^{-1}$ and 124.23 tCO_2, while in *Delonix regia* intake was 19.06$tCha^{-1}$

and 63.96 tCO_2 in Aurangabad city. The highest carbon sequestered percentage in *Albizia lebbek* at sector 7th (20%) and lowest at sector 1st (1%), while, in *Delonix regia* the highest in sector 7th (20%) and lowest in sector 1st (2%).

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