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Polyalthia longifolia: Carbon Dynamics

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ABSTRACT

There is a significant increase in pollution due to multiple man-made factors, hence conservative measures are "need of the hour". The effects of conditions like climate change and global warming are ever increasing. Increase in emission of toxic gasses into the atmosphere is turning into a serious threat to the ecology. The only solution is reduction or stabilization of harmful factors in the environment. This can be done through eco-friendly, non-destructive methods of carbon estimation like biomass assessment by measuring dimensions of the trees. *Polyalthia longifolia* is one such boon of a species that contributes greatly against pollution. The main objective is to study the *P. longifolia* species and estimate its biomass, to understand its carbon dynamics and evaluate the impact of the species against atmospheric pollution. A total of 70 trees of *Polyalthia longifolia* were considered under current study, present in the campus area of D.G. Ruparel College in Mumbai City, coordinates 19° 1' 40"NL & 72° 50' 42''EL. *P. longifolia* has sequestrated an average of 302.5528 kg/tree of Carbontill date and an average of 1109.3604 tons of CO_2 equivalent was obtained considering above ground biomass and below ground biomass of the tree. This study shows that the height and the Girth at breast height (GBH) of the tree have direct correlation which confirms that the height and GBH highly influence the carbon sequestration potential.

Key words : *Polyalthia longifolia*, *Carbon sequestration, Statistical analysis.*

Introduction

As time gradually passes by, there is a significant increase in pollution due to multiple man-made factors and therefore stabilization, hence conservative measures are "need of the hour". Emissions of detrimental gasses, particularly Carbon, are spiking at an alarming rate. The solution to this concern is awareness of the situation at hand and implementing appropriate measures to deconstruct the threat of these harmful emissions by using eco-friendly methods. Specifically Non-destructive methods. These methods include quantitative and qualitative analysis using visible parameters like Diameter (GBH), Height, etc. It takes comparatively less time and physical assessment of the tree can be done.

Tropospheric ozone is a major pollutant for humans at sustained exposures of 40 ppb or more in ambient air. *P. longifolia*, is a tree that accounts for 5-20% of the urban plantations in Indian cities therefore it is used as a model to estimate not only the stomatal O_3 uptake but also its capability to sequester other criteria air pollutants. (Parkar, 2020). This gives rise to the need to study the carbon dynamics and assess the biomass of the *Polyalthia* species.

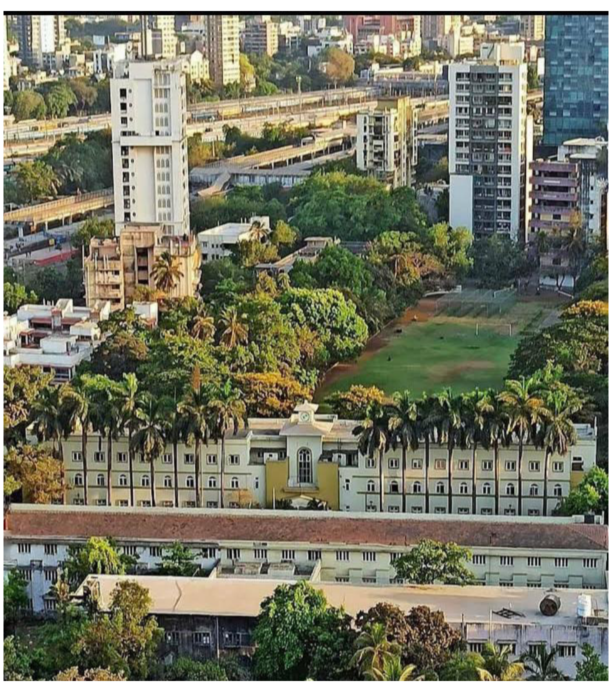
Species *P.longifolia*, belonging to the family Annonaceae, are trees or shrubs and are dioecious. Leaves are simple, alternate, glabrous, long, narrow and dark green. Fruits are borne in clusters of 10-20. Flowers are bisexual, solitary, leaf opposed, axillary, supra-axillary, pubescent, pedicellate and bracteate. Petals are greenish yellow. (Subhramanion, 2013) *Polyalthia longifolia* is native to the drier regions of India and is locally known as "False Ashoka". The bark of *P. longifolia* is available as one of the adulterants and used as Ashoka due to its easy availability in nature. This plant is used as an antipyretic agent in indigenous systems of medicine. Antimicrobial activity, cytotoxic function and hypotensive effects (Katkar, 2010).

Evergreen trees can grow up to a height of 15-20 meters tall. The longest branch is seen at the base and shorter at the end of the trunk, giving an appearance of conical crown. *P. longifolia* propagates through seeds and occasionally through soft air cuttings and air layering (Subhramanion, 2013). The wood is tough and flexible but of less durability. Bark is used medicinally as a febrifuge. The fruits at all times are eaten by birds or monkeys. This tree is a main attraction in gardens throughout India and is also in demand for garden planning such as avenue and driveway plantations, hedges, as privacy screens for pools and houses, etc.

Materials and Methods

Geographical Location of the Area and Sampling

The D.G. Ruparel college situated in Maharashtra, Mumbai, on western coastal region of India is selected for the present comparative study of various physical factors and their contribution to carbon Sequestration of *Polyalthia longifolia* tree species. It is geographically located at 19° 1′40"N Latitude and



72° 50' 42"E Longitude. It was established in 1952, located in Mahim, Mumbai suburban. The D.G. Ruparel College is situated in the heart of Mumbai city, with over 400 trees in record, tree species ranging from larger and older trees like *Ficus benghalensis* to smaller trees of *Areca catechu* are seen in the campus (Mithbavkar *et al.*, 2022). This campus has a large number of *Polyalthia longifolia* trees. A total of 70 *P. longifolia* trees of varying height and girth spread over 10 acres of area have been selected under current study. The tree species were identified by the name and species tags (QR codes) given to the trees by the college.

The comparative analysis of *P. longifolia* trees were recorded over a period, from June to September of 2022. The tree species was selected on the basis of species richness and species abundance in the college. Calculation of all biological parameters along with annual carbon sequestration by *P. longifolia* species with the help of girth and height of the tree was done by non-destructive method, in this method we need not cut down the entire tree. (Avhad, 2021)

Volume and Biomass Estimation

Polyalthia longifolia was considered for estimation of volume and total biomass; 70 trees of different diameters (>15 inches) and heights were selected for measurement. Indirect method- calculated using Above ground biomass (AGB) and Below ground biomass (BGB) without cutting the trees. (Sahu, 2020).

Allometric methods were used for estimation, girth at breast height (GBH) of trees was measured using a measuring tape at a height 1.22 m from the ground. The height of the trees was calculated using **Abney Level** (an instrument used for the measurement of slopes) for which the distance between the tree (whose height was to be found) and height of the person using the Abney level along with the angle that coincided with the tip of the tree, was noted (Mithbavkar *et al.*, 2022)/

- Formula for calculating height of the tree = Tan ´ of observed angle(noted)× horizontal distance (noted)

The AGB and BGB was calculated by:

- Basal area(m^2) = $(GBH)^2/4ð$
- Bio-volume (m^3) =Basal area× Height of the tree
- AGB (kg)= Bio-volume × wood density (kg/m^3)[6]
- BGB (kg)= AGB x 0.26

where, 0.26= Root to shoot ratio

- Total Biomass (TB) in kg/tree= AGB+BGB
- Total Carbon Sequestration (TC) in kg/tree= TB/2

The CO_2 equivalent was calculated using formula:

- CO_2 equ. = (TC×44)/12

Where, 44 and 12 are the molecular and atomic weight of CO_2 and C, respectively. The wood density of individual species was obtained from the literature in (Mithbavkar *et al.*, 2022) (Kale, 2022)

Statistical tests

Correlation

Correlation measures the strength of association between variables. In correlated data, the change in magnitude of 1 variable is associated with change in the magnitude of another variable, either in the same (positive correlation) or in the opposite (negative correlation) direction. Both correlation coefficients are scaled such that they range from -1 to +1, where 0 indicates that there is no linear or monotonic association. (Schober, 2018)

t-Test: Student's t-test of two samples assuming unequal variance

This test is a modified version of t- test and can be applied when

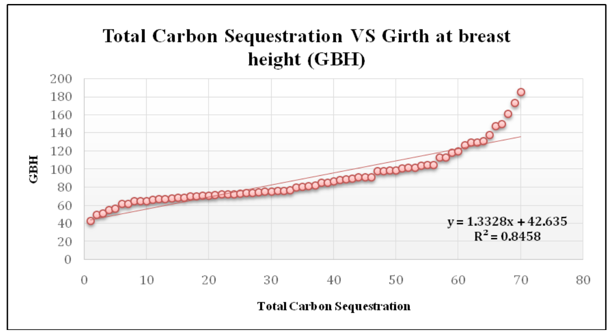
(1) The samples are normally distributed,
(2) The standard deviation of both populations is unknown and is assumed to be unequal,
(3) Sample is sufficiently large i.e. Over 30.

Observations

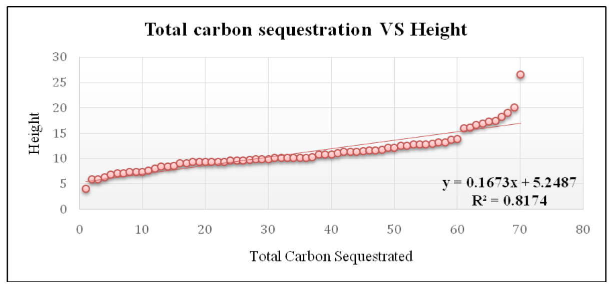
Results

Research articles addressing carbon estimation; tell us that the carbon sequestration potential of the trees varies due to multiple factors such as wood densities, varying Girth at breast height (GBH), and height of the trees. Therefore, evaluation of these parameters is necessary to conduct activities such as strategic tree plantations to manage carbon emissions and to determine plant species, which sequester carbon at a higher rate. *Polyalthia* species of varying diameters (GBH) and height were selected, to co-relate it with total carbon sequestrated. By using GBH, height, AGB, BGB and total biomass, Carbon sequestration by this species was calculated. An average of 302.5528 kg of carbon was sequestrated till date, followed by the average of carbon dioxide equivalent i.e., 1109.3604 tons which was estimated using above stated formulae in the methodology. (Mithbavkar *et al.*, 2022)

Correlation



Graph 1. Total Carbon Sequestration VS Height



Graph 2. Total Carbon Sequestration VS Girth at breast height.

From the above shown graphs, the following interpretation can be done:

Graph No.	R2 value	R value	Correlation
1	0.8458	0.9196	Moderate positive correlation
2	0.8174	0.9041	Moderate positive correlation

- There exists a Moderate positive correlation between the Total carbon sequestrated and GBH
- There exists a Moderate positive correlation between the Total carbon sequestrated and Height of the tree.

t-Test: Student's t-test of two samples assuming unequal variance

As the standard deviation is unknown, the data is assumed to be normally distributed and the sample size is also large, the two sample T-Test can be applied to analyze the data. Hence for acquiring this data girth at breast height (GBH) was divided as, GBH <114 cm and GBH >114 cm and height was divided as, Height<11.29 m and Height>11.29 the

Table 1. Girth at breast height (GBH), Height, Above ground biomass (AGB), Below ground biomass (BGB), Total Biomass (TB), Total Carbon Sequestrated (TC) and Carbon dioxide Equivalent of *P. longifolia*

Sr. No.	GBH (cm)	Height (m)	AGB (kg)	BGB (kg)	TB (kg/ tree)	TC (kg/tree)	CO_2 equivalent
1.	43	11.7640	102.1775	26.5661	128.7436	64.3718	236.0300
2.	50	6.3261	74.2914	19.3158	93.6071	46.8036	171.6130
3.	51	7.1061	86.8228	22.5739	109.3968	54.6984	200.5607
4.	55	7.4085	105.2738	27.3712	132.6450	66.3225	243.1824
5.	56.13	9.3313	138.1000	35.9060	174.0060	87.0030	319.0110
6.	62	10.2035	184.2448	47.9036	232.1484	116.0742	425.6054
7.	62	10.2745	185.5269	48.2370	233.7639	116.8820	428.5672
8.	64.5	11.3738	222.2730	57.7910	280.0639	140.0320	513.4506
9.	65	8.5190	169.0742	43.9593	213.0335	106.5168	390.5614
10.	65	11.0274	218.8587	56.9033	275.7619	137.8810	505.5635
11.	66.54	13.2329	275.2225	71.5578	346.7803	173.3902	635.7639
12.	67	9.2905	195.9085	50.9362	246.8447	123.4224	452.5487
13.	67.31	9.6090	204.5023	53.1706	257.6728	128.8364	472.4002
14.	67.56	12.7788	273.9890	71.2371	345.2261	172.6131	632.9146
15.	68.58	10.2005	225.3621	58.5941	283.9562	141.9781	520.5864
16.	68.58	12.9320	285.7094	74.2844	359.9938	179.9969	659.9886
17.	69.85	8.3878	192.2399	49.9824	242.2223	121.1111	444.0741
18.	70.1	9.6090	221.8068	57.6698	279.4766	139.7383	512.3738
19.	71.12	9.3313	221.7109	57.6448	279.3558	139.6779	512.1523
20.	71.12	10.8471	257.7276	67.0092	324.7367	162.3684	595.3507
21.	71.37	12.7788	305.7632	79.4984	385.2617	192.6308	706.3130
22.	72.39	18.2165	448.4186	116.5888	565.0074	282.5037	1035.8469
23.	72.39	6.8466	168.5363	43.8194	212.3558	106.1779	389.3189
24.	72.64	10.2005	252.8352	65.7372	318.5724	159.2862	584.0494
25.	73	16.7073	418.2296	108.7397	526.9693	263.4847	966.1105
26.	73.66	7.4290	189.3466	49.2301	238.5768	119.2884	437.3907
27.	74	10.8471	279.0235	72.5461	351.5696	175.7848	644.5443
28.	74.93	26.6476	702.7993	182.7278	885.5271	442.7635	1623.4663
29.	75.18	7.4290	197.2417	51.2828	248.5246	124.2623	455.6284
30.	75.43	10.2005	272.6303	70.8839	343.5142	171.7571	629.7760
31.	76	9.8241	266.5518	69.3035	335.8553	167.9277	615.7347
32.	76.2	15.9997	436.3993	113.4638	549.8631	274.9315	1008.0823
33.	76.7	10.8471	299.7562	77.9366	377.6928	188.8464	692.4367
34.	80	10.1119	304.0008	79.0402	383.0410	191.5205	702.2418
35.	80.77	11.4039	349.4749	90.8635	440.3384	220.1692	807.2871
36.	81.28	9.0650	281.3180	73.1427	354.4607	177.2304	649.8447
37.	81.78	11.4256	358.9507	93.3272	452.2779	226.1389	829.1761
38.	85	13.8110	468.7320	121.8703	590.6023	295.3011	1082.7709
39.	85.09	13.2329	450.0651	117.0169	567.0820	283.5410	1039.6504
40.	86.36	20.0435	702.2019	182.5725	884.7744	442.3872	1622.0864
41.	88	16.1488	587.4453	152.7358	740.1811	370.0906	1356.9987
42.	88.9	8.0081	297.3007	77.2982	374.5989	187.2994	686.7646
43.	90	5.8563	222.8301	57.9358	280.7659	140.3829	514.7374
44.	91	19.0125	739.5787	192.2905	931.8691	465.9346	1708.4268
45.	91.5	9.8980	389.2729	101.2109	490.4838	245.2419	899.2204
46.	91.5	9.8980	389.2729	101.2109	490.4838	245.2419	899.2204
47.	98	7.0474	317.9405	82.6645	400.6050	200.3025	734.4426
48.	98	12.8027	577.5845	150.1720	727.7564	363.8782	1334.2201
49.	99	12.1046	557.2927	144.8961	702.1888	351.0944	1287.3461
50.	99.06	5.8803	271.0573	70.4749	341.5322	170.7661	626.1424
51.	101.34	9.3100	449.1318	116.7743	565.9061	282.9531	1037.4946

Table 1. *Continued ...*

Sr. No.	GBH (cm)	Height (m)	AGB (kg)	BGB (kg)	TB (kg/ tree)	TC (kg/tree)	CO_2 equivalent
52.	102	9.3313	456.0411	118.5707	574.6118	287.3059	1053.4549
53.	102	12.1369	593.1577	154.2210	747.3786	373.6893	1370.1942
54.	104.14	12.5155	637.5987	165.7757	803.3743	401.6872	1472.8530
55.	105	9.3027	481.7836	125.2637	607.0474	303.5237	1112.9202
56.	105	17.3455	898.3142	233.5617	1131.8759	565.9379	2075.1057
57.	113	11.6300	697.5861	181.3724	878.9585	439.4793	1611.4240
58.	113	9.5668	573.8317	149.1962	723.0279	361.5140	1325.5512
59.	118	7.6393	499.6641	129.9127	629.5768	314.7884	1154.2241
60.	120	11.5930	784.1860	203.8884	988.0744	494.0372	1811.4697
61.	126.74	11.3738	858.2121	223.1351	1081.3472	540.6736	1982.4699
62.	129.54	9.7073	765.1902	198.9494	964.1396	482.0698	1767.5893
63.	129.54	13.7530	1084.0995	281.8659	1365.9654	682.9827	2504.2698
64.	130.81	9.0650	728.6384	189.4460	918.0844	459.0422	1683.1548
65.	137.92	10.1119	903.5438	234.9214	1138.4652	569.2326	2087.1862
66.	148	12.5255	1288.7912	335.0857	1623.8769	811.9385	2977.1077
67.	150	8.4822	896.5027	233.0907	1129.5934	564.7967	2070.9212
68.	161.29	4.0566	495.7291	128.8896	624.6187	312.3093	1145.1342
69.	173.22	17.4573	2460.5712	639.7485	3100.3197	1550.1599	5683.9195
70.	185.42	16.8527	2721.7369	707.6516	3429.3885	1714.6943	6287.2123
AVG				605.1057	302.5528	1109.3604	

interpretations were as follows:

t-Test: Two-Sample Assuming Unequal Variances for Total carbon

	GBH <114	GBH >114
Mean	218.6547	708.0604
Variance	13741.0001	206531.6666
Observations	58.0000	12.0000
Hypothesized Mean Difference	0.0000	
Df	11.0000	
t Stat	-3.7051	
P(T<=t) one-tail	0.0017	
t Critical one-tail	1.7959	
P(T<=t) two-tail	0.0035	
t Critical two-tail	2.2010	

Interpretation

We reject the null hypothesis because the p- value (0.0017) is smaller than the level of significance (0.05) therefore the values of total carbon sequestration are dependent on the GBH of the tree.

t-Test: Two-Sample Assuming Unequal Variances for height

	height <11.29	height >11.29
Mean	204.8333	440.7080
Variance	16442.2886	136923.3639
Observations	41.0000	29.0000
Hypothesized Mean Difference	0.0000	
Df	33.0000	
t Stat	-3.2956	
P(T<=t) one-tail	0.0012	
t Critical one-tail	1.6924	
P(T<=t) two-tail	0.0024	
t Critical two-tail	2.0345	

Interpretation

We reject the null hypothesis because the p- value (0.0012) is smaller than the level of significance (0.05) therefore the values of total carbon sequestration are dependent on the height of the tree.

Discussion

During the period of growth of a seedling into a tree, it accumulates or fixes carbon through a process called photosynthesis. From an ecological point of view, it can be stated that both GBH and tree height influences carbon sequestration (Tripathi, 2015). Therefore, certain attempts can be made to enhance the potential of carbon sequestration, they are as follows:

- Tree plantation drives can be conducted
- Trees can be strategically grown around the in-

dustries to stabilize carbon dioxide in the atmosphere.
- Cutting of older trees should be prevented as they possess greater GBH and height, leading to efficient carbon sequestration.

Conclusion

Polyalthia longifolia was selected to study its carbon dynamics given its parameters, also determining its carbon sequestration potential. The above conducted study also shows that the height and the Girth at breast height (GBH) of the tree shows direct correlation. This confirms that height and GBH greatly influence the carbon sequestration potential (Mithbavkar *et al.*, 2022).

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Conflict of interest

The Author(s) declare(s), there is no conflict of interest.

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