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Sequestration of Carbon and Oxygen Production in Upper Stands in The Arboretum of PT Arutmin Indonesia NPLCT

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Biomass, Carbon stocks, Carbon sequestration, Oxygen, Arboretum.

ABSTRACT
This study aims to determine biomass, carbon, carbon uptake, and oxygen production in the arboretum of PT. Arutmin Indonesia-NPLCT. The methods used are purposive sampling and allometrics. The plot size useda is 20 m × 20 m with 12 plots measured. The area of the arboretum is 5.05 ha. Carbon stock measurement is done by multiplying biomass by a conversion rate of 0.47 (47%) while carbon dioxide (CO2) sequestration is calculated by multiplying the average annual biomass growth by the conversion rate of 1.4667 obtained from the photosynthesis equation and oxygen production is measured based on conversion from carbon yield. Based on the results of the study, it showed that the biomass content of stands in the arboretum was 1,067.32 tons, carbon stocks were 501.64 tons, carbon dioxide (CO2) absorption was 1,565.45 tons, and oxygen production was 1,337.71 tons.

INTRODUCTION

Indonesia's forests are the richest and most diverse forests on earth. The Indonesian government owns more than 120 million hectares of secret forest in the country, almost twice the size of France. Of the 4,444,120 million hectares, Indonesia's forests are divided into three categories. This means that 18% is parkland, 25% is conservation forest, and 57% is production forest. A total of 69 million hectares of forest is designated for construction. However, only 45% of land is granted permits to private companies as natural production forests or plantation forests. The remaining 55% of productive forests are outside the lease system and are particularly vulnerable because there are no institutions to guarantee the management of these forests.

Trees or forests are the world's lungs since numerous trees have become one of the biggest oxygen makers (Bandara & Dissanayake, 2021; Han et al., 2023; Yang et al., 2023). Where oxygen could be an essential requirement in human life. Woody vegetation, especially trees, provides many benefits that can improve the quality of the environment and human health in and around urban areas (Batkhuyag et al., 2023; Chaudhary & Aryal, 2023; Kala, 2023; Miranda Verly et al., 2023). These benefits include improved air and water quality, energy savings in buildings, cooler air temperatures, reduced UV radiation, and many other environmental and social benefits (Nowak et al., 2007). Fast-growing woody plants can absorb more carbon than slow-growing plants. Faster-growing vegetation often has difficulty measuring its ability to sequester carbon (Kongboon et al., 2022; Singh et al., 2023; Swamy et al., 2023; Wang et al., 2024). Forest plays a role in increasing CO_2 absorption through sunlight and soil water. Chlorophyllous plants can absorb CO2 from the atmosphere (Kumari et al., 2023; Mohammadi et al., 2023; Sribianti et al., 2022).

Through photosynthesis, the results are among other things, stored as biomass, allowing plants to grow larger or taller. This growth will continue until the vegetation stops growing physiologically or is harvested (Song et al., 2024; Wu et al., 2023; Zhou et al., 2023). With sustainable

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forests, more carbon (C) is stored and longer. Therefore, planting vegetation on bare land or restoring destroyed forests will help absorb excess CO2 in the atmosphere (Bajuin, 2018; Birungi et al., 2023; Namin et al., 2020).

The distinctive focus of this research centers on the Arboretum of PT. Arutmin Indonesia-NPLCT is an ecological setting characterized by its unique vegetation composition and environmental conditions. While existing literature acknowledges the general importance of forests in carbon absorption and oxygen production, this study seeks to contribute to the existing body of knowledge by unraveling the intricacies of these processes within the specific context of an arboretum dedicated to reforestation and ecological restoration.

Unlike broader studies that encompass carbon absorption in various forest ecosystems, this research scrutinizes the effectiveness of reforestation efforts. Doing so provides insights that may diverge from findings in other forested areas. Moreover, the study may integrate innovative methodologies and technologies, such as advanced sensor technologies or spatial mapping, thereby enhancing measurement precision and setting itself apart from previous research endeavors.

By explicitly highlighting these distinctive aspects, the research positions itself as a valuable addition to the scientific discourse on forest ecosystems and emphasizes its potential to refine environmental management strategies. This is particularly relevant in sustainable practices within arboretums, underscoring the significance of the study's potential contributions to advancing ecological restoration and management practices.

METHODS

The research was conducted at the Arboretum of PT. Arutmin Indonesia-NPLCT,Jl. Berangas Km. 5,5 Tanjung Pemancingan Sarang Tiung village, Kotabaru Regency, South Kalimantan. The time required to carry out this research is 2 months.

The tools used are GPS (Global Positioning System), cameras for documentation tools, meters to measure distances, measuring tapes to measure diameters. The object in this study, is the stand on the tree contained in the Arboretum of PT. Arutmin-NPLCT.Tree Measurement at the study site. The data collected or obtained from the field is diameter. The biomass formula used is:

Top Biomass Measurement

Table 1. Biomass Calculation Formula

Types of Vegetation	Formula	source
Acacia	$Y=0,060255 \times D^{2,39}$	Purwitasari (2011)
Tropics Common (Branching Tree)	$Y=0,11 \times \rho \times D^{2,62}$	Ketterings et,al., (2001)
Palm <1,3 m	Y = 0,0976 H+0,0706	ICRAF (2009)
Palm >1,3 m	Y = 0,002382 × D 2,3385 × H0,9411	Lubis (2011)

Information:
Y = Biomass (kg)
H = Tree Height (m)
D = Diameter at Chest Level (dbh) (cm)
ρ = Wood Density/Specific Gravity (mg/m^3, kg/m^3, atau g/m^3)

Bottom Biomass Measurement

Measurement of biomass under the root part of the plant. The formula used is:

$$Bb = Ba \times 0,25$$

Information:
Bb = Bottom Biomass (kg)
Ba = Top Biomass (kg)
0,25 = Constant Value (IPCC,2006)

Carbon (CO_2) From Biomass
Calculation by Formula (IPCC, 2006) is:

$$C = \text{Biomass} \times \text{ \%C-Organik}$$

Information:
C = Carbon from Biomass (kg)
B = bioresource Total (kg)
%C Organik = 0,47% (SNI 7724, 2011)

Reserve Carbon for Ha for Plot
The carbon value per ha for data on the soil surface is:

$$Cn = \frac{\text{Cx}}{1000} \times \frac{10.000}{Lplot}$$

Information:
Cn = Carbon pool on plot (ton/ha).
Cx = Carbon pool on plot (kg).
Lplot = Area of plots in each carbon pool (m2) (SNI 7724, 2011)

Sequestration Karbon (CO_2)
Sequestration CO_2, rumus ialah:

$$\text{Sequestration } CO_2 = \text{Biomass (kg)} \times 1{,}4667$$

Information
1,4467 = The conversion value obtained from the photosynthetic equation (Baharuddin et al., 2014).

Conversion of Carbon Biomass to Oxygen (O_2)

1. **CO_2- equivalent**
   The calculation uses a ratio of the relative atomic mass of C (12) and the passive molecular mass of CO_2 (44) with the formula (Kemenhut,2013) :

$$CO_2 - \ ekuivalen = (\frac{44}{12}) \times \text{C}$$

2. **Oxygen Production (O_2)**
   Oxygen production/release is calculated based on the amount of oxygen produced during photosynthesis minus the amount used during plant respiration. The amount of oxygen production can be estimated from carbon sequestration based on atomic weight (Ross and Salisbury, 1978):

$$Net\ O^2 = net\ C \times \frac{32}{12}$$

The determination of carbon storage measurement plots is carried out with the following sizes: Plot size: "20m × 20m."

Sampling using purposive sampling and sampling methods without harvesting or logging. This sampling method involves measuring the height of oil palms and tree diameters by applying allometric equations to extrapolate biomass. Determination of the number of tiles that the measurement takes, using 10% IS. Based on Boon and Tideman (1950) for forests whose area ≥ 1,000 ha IS used 2%, while the area < 1,000 ha IS used 5% to 10%. Based on the area in the Arboretum of PT. Arutmin NPLCt is 5.05 ha.

The parameters measured are (dbh ≥ 10 cm and ≥ height 1.5 m) by measuring the diameter of the tree stand. Form a stand plot like Figure 1.

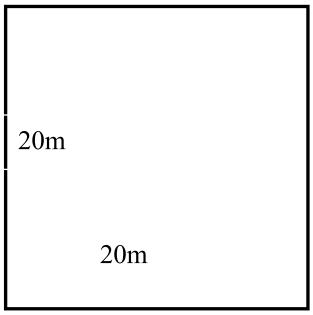

Figure 1. Plot Size Shape

RESULTS

Based on stand diameter measurements that have been carried out in the arboretum of PT. Arutmin Indonesia-NPLCT. The results obtained are biomass average 211.351 tons/ha, average carbon 99.33 tons/ha, carbon absorption 309.98, average CO2-equivalent 364.22, and average oxygen production 264.894 tons/ha. The results of these results can be seen in Table 2.

Table 2. Total Biomass, Carbon Stocks, Carbon Sequestration, CO2-equivalent, and Oxygen Production in Arboretums

No.Plot	Biomass Total (Ton/Ha)	Carbon Total (Ton/Ha)	Sequestration Carbon (Ton/Ha)	CO2-Ekuivalen (Ton/Ha)	Production Oksigen (Ton/Ha)
1	270,75	127,25	397,10	466,59	339,33
2	11,58	5,44	16,98	19,95	14,51
3	93,50	43,95	137,14	161,14	117,19
4	153,72	72,25	225,46	264,91	192,66
5	277,86	130,59	407,53	478,84	348,25
6	28,42	13,36	41,68	48,97	35,62
7	307,72	144,63	451,33	530,30	385,67
8	141,64	66,57	207,74	244,09	177,52
9	314,84	147,98	461,78	542,58	394,60
10	594,16	279,26	871,46	1023,94	744,68
11	153,88	72,32	225,69	265,18	192,86
12	188,16	88,43	275,97	324,26	235,83
Average	**211,351**	**99,335**	**309,989**	**364,229**	**264,894**
TOTAL	**2536,22**	**1192,02**	**3719,87**	**4370,75**	**3178,73**

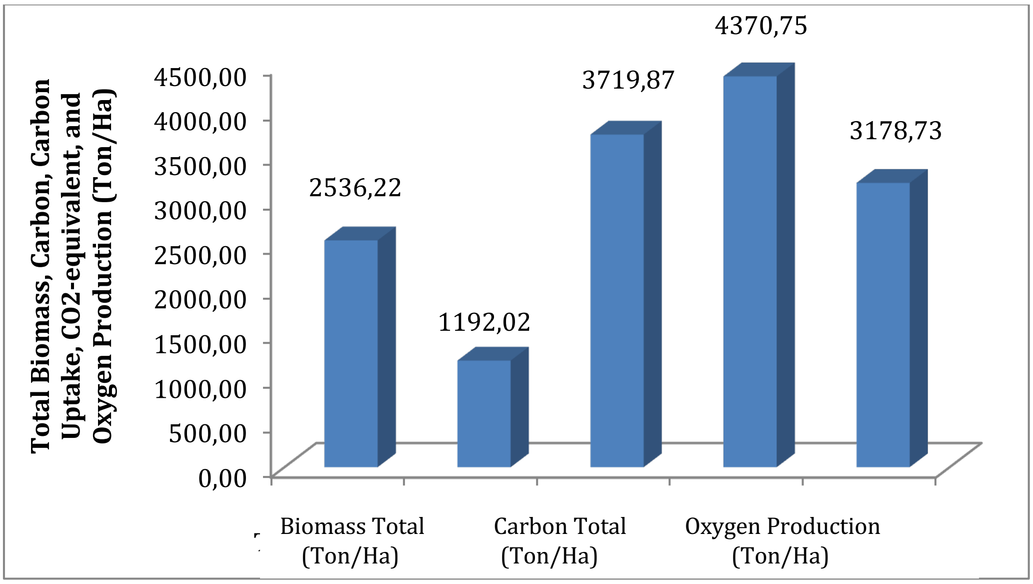

Figure 2. Diagram of total biomass, carbon, carbon sequestration, CO_2-equivalent, and oxygen production (ton/ha)

Arboretum located in the area of PT. Arutmin Indonesia-NPLCT covering an area of 5.05 ha. The results obtained for total biomass, total carbon, total uptake, CO_2-equivalent and total oxygen production in the area can be seen in table 3.

Table 3. Total Biomass, Carbon Stocks, Carbon Sequestration, CO_2-Equivalent, and Oxygen Production in an Arboretum covering an area of 5.05 ha

No	Arboretum Area (Ha)	Average Biomass (Ton/Ha)	Average Carbon (ton/ha)	Average Carbon Sequestration (ton/ha)	Average CO_2-Ekuivalen (ton/ha)	Average Oxygen Production (ton/ha)
1	5.05	211,35	99,34	309,99	364,23	264,89
		Biomass Total (Ton)	Carbon Total (ton)	Carbon Sequestration (Ton)	CO_2- Ekuivalen (Ton)	Oxygen Production (Ton)
2		1.067,32	501,64	1.565,45	1.839,36	1.337,71

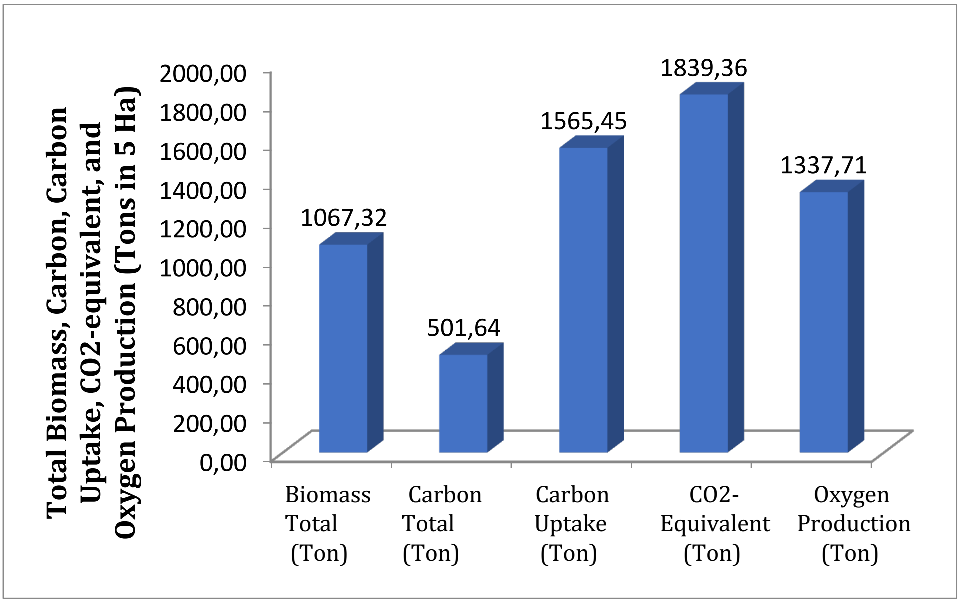

Figure 3. Diagram of total biomass, carbon, carbon sequestration, CO2-equivalent, and oxygen production in an area of 5.05 ha (tons)

Based on figure 3, it can be seen that the results obtained from the calculation of the biomass of tree stands in the arboretum covering an area of 5.05 ha. Carbon produced amounted to 501.64 tons, carbon absorption amounted to 1565.45 tons, and oxygen production 1,337.71 tons. Based on the calculation results of oxygen production produced in the arboretum area of PT. Arutmin Indonesia-NPLCT with an area of 5.05 Ha. The oxygen production produced amounted to 1,337.71 tons. According to the global oxygen budget and its future article published in the science bulletin. Each adult needs 1.17 kg of oxygen per day. It can be known that the production of oxygen produced in the arboretum is 371,586 kg / day. So that it can meet the daily oxygen needs of adults as many as 317,000 people per day.

According to technical guidelines for planting tree species absorbing air pollutants published by the Ministry of Environment and Forestry (2015), it is said that 1 ha of green open space (RTH) filled with large trees, oxygen production produced is 0.6 tons for 1,500 residents / day and carbon dioxide absorption is 2.5 tons / year.

Based on calculations that have been done by weighing the results obtained in the average standard carbon production that has been obtained, the results exceed what has been planned using purposive and allometric methods so that what stands are measured only the stem with this purpose can be known that what is done is comparable to the greater than the average oxygen produced.

The value obtained based on what will be done with what will happen with this can be known that the gains that have been taken with what is known value by reviewing the location and measuring diamete trunks or tree stands can be seen that the results obtained are quite large for various sizes with the conditions of stands around us so that what is obtained is the same as what is in previous studies when compared The result is that the carbon production produced is very large in the arboretum area, which is 5.05 ha.

CONCLUSION

The arboretum at PT. Arutmin Indonesia-NPLCT boasts impressive ecological metrics, with an average biomass content of 211.35 tons/ha, a carbon stock of 99.34 tons/ha, carbon dioxide absorption reaching 364.23 tons/ha, and a substantial oxygen production of 264.89 tons/ha. These figures, coupled with a total biomass area of 5.05 ha, totaling 1,067.32 tons, and corresponding carbon stocks, oxygen production, and CO2 absorption, underscore the arboretum's vital role in supporting a thriving ecosystem. To better comprehend these results, it is essential to interpret them in the context of environmental significance. Comparisons with established benchmarks could provide readers with a frame of reference to evaluate the arboretum's effectiveness in biomass content, carbon stock, and oxygen production. Acknowledging study limitations, such as seasonal variations or site-specific conditions, is crucial for transparency and a more comprehensive understanding. Recommendations for optimizing carbon sequestration or biomass content could enhance the arboretum's ecological impact, making it a valuable area for future research and management strategies. In conclusion, the significant oxygen production of 371,586 kg/day positions the arboretum as a potential contributor to meeting the daily oxygen needs of around 317,000 people, emphasizing its importance in the broader environmental landscape.

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