

A Review Of The Potential Of Calliandra As A Biomass Power Plant

Bunga Karuni Putri¹, Citra Salsabila¹, Firdaus¹, Erda Rahmilaila Desfitri^{1*}
¹Renewable Energy Engineering Technology, Universitas Bung Hatta, Padang
*rahmilaila@bunghatta.ac.id

ABSTRACT

Massively, the use of fossil energy poisons the earth with pollution, and the environment is damaged due to the resulting waste. The existence of renewable energy, such as biomass, can be an existing solution. One example is the calliandra plant, which can be helpful in many ways. This paper uses the literature review method to show that Calliandra is not only used as livestock feed but could also be used as co-firing fuel as an electric source. The calorific value of kaliandra is 4,200 kcal/kg more significant than the hybrid technique for paddy straw, sawdust, and binder, respectively, yielding a CV (calory value) of 3745 kcal/kg and more petite than wood fuels with calorific values of 13,130 kcal/kg. Calliandra is very suitable for internal fuel because its calorific value is relatively high, and the planting process is quite easy compared to wood. Calliandra can be used as the co-firing material as biochar with a pyrolysis process.

Keywords: biomass; biochar; calliandra; co-firing.

INTRODUCTION

Regarding energy use, the world is still very dependent on non-renewables or fossil energy. The massive use of fossil energy allows the earth to be poisoned by pollution, the environment is damaged due to the waste generated, and greenhouse gas emissions will increase. Therefore, renewable energy can be used freely. Its abundant availability does not produce pollution and carbon emissions and makes the independent community strive for its energy.

The existence of the cofiring PLN Program is to mix biomass fuel with coal on the PLTU, which will clearly encourage users of biomass as a source of energy. Biomass is a term used to refer to all organic compounds from agriculture, algae, and organic waste in renewable energy. One of them is calliandra, a genus of a group of peas that bear peas (legumes) (Stewart, 2001) . The quality and quantity of fuel calliandra also optimizes land use, including being integrated with farms, and can be harvested repeatedly without replanting (replanting) for the next harvest. Even because the energy garden plant uses legumes such as calliandra, whose roots can bind nitrogen from the atmosphere, soil fertility increases.

Based on this, the purpose of the review is to determine the quality of Calliandra as the source of biomass and the method of using Calliandra as raw material biomass, especially in terms of Biomass Power Plants.

MATERIALS AND METHODS

The writing of this Paper uses the literature review method. Review literature is systematic and explicit about identifying, evaluating, and synthesizing works on research results and results of thought that have been produced by researchers and practitioners (Green et al, 2006) . The criteria used as a significant source are articles that use Indonesian and English, articles from within and abroad, articles that come from based data in the form of science director, MDPI, Research Gate, and Google Scholar, and articles published in full text. The object of research used in the article is Calliandra.

RESULTS AND DISCUSSION

Based on the description of the method above, this article is used by several 4 (four) scientific articles chosen as the main article to answer the study's goals. The author found several ways to care for and utilize Calliandra from the article, as displayed in Table 1.

Table 1. Research on the use and processing of Calliandra in the field of biomass

Article Title and Publisher	Author & Year Issued	Description of The Paper
<i>Growth of Calliandra Seedling on Different Block Seedling Media Compositions in Nursery and Field. Plant Research.</i> (<i>Pertumbuhan Bibit Kaliandra Pada Beberapa Komposisi Media Semai Cetak Di Persemaian Dan Lapangan. Penelitian Hutan Tanaman</i>)	Suita, et al., 2017	Calliandra seedlings grown in print media have better growth than seeds in polybags. The composition of the KM-3 (40% compost + in the 20% husk of + land 20% + Kaptan 10% + tapioca 10% + rhizobium 3 g) provides the best result for height, diameter, and dry weight of the seedlings in remains.
<i>The Effect of Torefaksi Temperature Variations on Color Changes and Physical Properties Pellet (Calliandra Calothyrsus). Forestry Science (Pengaruh Variasi Suhu Torefaksi Terhadap Perubahan Warna Dan Sifat Fisik Pelet Kaliandra (Calliandra Calothyrsus). Ilmiah Kehutanan)</i>	Mauritio, P., 2020	Torrefaction is the thermal treatment that can address most problems related to biomass quality as fuel. The effect of temperature on changes in color and characteristics of the Calliandra pellet is increasing the temperature used when performing torrefaction, the pellets will change color darker, and the color has changed entirely from the initial color as a result of the hemicellulose product split reaction produced by the material during the torrefaction process. The characteristics of Calliandra can also change with rising temperature. The pellet experienced heavy loss due to water content, and other substances within the pellets were degraded.
<i>Harvesting Strategies for Improved Mixtures of Calliandra and Napier Grass in the Central Kenyan Highlands</i>	Nyaata, O.Z., et al., 2008	A study on the harvesting management of Calliandra in association with Napier grass for forage production was carried out on a typical Paleustalf soil receiving 906 and 1,465 mm of total annual rainfall during 1996 and 1997, respectively. Pure stands of Napier grass and Calliandra were compared with Napier grass: Calliandra mixture in a 2:1 row combination during the first two years after planting. Results obtained indicate that once established, sufficient Calliandra can be produced from one hectare of the mixture to provide recommended levels of supplement feed for two lactating dairy cows.
<i>Training in Biochar Production from Rice Husk Using Retort Kiln Method. Science Journals.</i>	Maria, M. et al., 2017	The process of burning husks to biochar through three methods, namely using combustion poles, retort kiln's drum, and the open system used to the public use ramp wire.

<i>Biomass Technology for Electricity Generation in Community. Renewable Energy</i>	Mirko Barz, 2008	The technology to generate electricity from biomass through combustion is very sophisticated. Many applications use different power generation principles (steam turbines, threaded-in-machine type, ORC turbines). Due to the logistical conditions of biomass production, storage, and transportation, as well as the possibility of using hot energy for community warming, decentralized power generation is the most economical solution. A similar status is found in biochemistry conversion technology (e.g., biogas technology) or physio-thermic.
<i>Adaptation and Productivity of Calliandra for Biomass Energy Source. Earth and Environmental Science</i>	Siarudin, M. et al., 2020	The treatment of spacing applied is 4 m x 1 m or a density of 2,500 trees/ha (J1), 4 m x 2 m or a density of 1,250 trees/ha (J2), and 4 m x 2 m with stripe or a density of 1,850 trees/ha (J3). The results of this study indicate that the J2 treatment showed the best level of adaptation with a survival rate of 89.3%, followed by treatments J3 and J1 with a survival rate of 85.9% and 84.4%, respectively.
<i>Potential Calliandra (Calliandra Calothyrsus) And Gamal (Gliricidia Sp.) In Yogyakarta, there is a special area for wooden pellets development. (Potensi Kaliandra (Calliandra Calothyrsus) dan Gamal (Gliricidia Sp.) di Daerah Istimewa Yogyakarta untuk Pengembangan Pelet Kayu)</i>	Fikri Maulana et al., 2021	The amount grown varies between 0 - 2000 Calliandra/ha trees and 0 - 3000 Gamal/ha trees. Based on the results, it is known that. The potential types for wooden pellets, Calliandra and Gamal have been planted in the 4 regencies. However, both types of planting need to be developed to support the production of wooden pellets.
<i>Kaliandra (Calliandra calothyrsus) as a Timber for Energy: in a Point of View of Seeds and Seedlings Procurement</i>	Dida, S. et al., 2014	The seedlings Calliandra, either from seeds or shoot cuttings, responded well to the given treatments.
<i>The Usage of Rhizobium and Mycorrhizae On The Growth Of Calliandra's Seedling (Calliandra Callothyrsus) At 5 Month Age. (Penggunaan Rhizobium dan Mikoriza Dalam Pertumbuhan Bibit Kaliandra (Calliandra Callothyrsus) Umur 5 Bulan)</i>	Kurniaty et al., 2013	Inoculation for mycorrhiza concurrently with rhizobium lowered rhizobium's effectiveness in increasing the seedling's growth. Therefore, it is recommended to use rhizobium or mycorrhiza isolated from Calliandra or other types but first tested compatibility.

<i>The Effect of Biochar Combinations and Remaining Loom on Availability of N and Soil P and Co 2 Emissions on Dry Land. (Pengaruh Kombinasi Biochar dan Sisa Tanaman Legum Terhadap Ketersediaan N dan P Tanah Serta Emisi Co 2 Pada Lahan Kering)</i>	Ningtyas et al., 2015	Materials used are fresh biomass, soil and biochar. Fresh biomass of four species of wild plants <i>Mucuna pruriens</i> (MP), <i>Psophocarpus tetragonolobus</i> (PT), <i>Phaseolus lunatus</i> (PL) and <i>Dolichos lablab</i> (DL), biochar rice hulls, bottles 100 mL plastic tube the size of 3 mL and 5 mL tube size Observations of soil N and available P were conducted at weeks 1, 2, 4, 6, and 8. The results indicated that the combination treatment of 75 MP + 25 AH (<i>Mucuna pruriens</i> 3,75 t ha-1 and 1.25 t biochar ha-1) had the highest value for ammonium in (8 MSI) that was equal to 143 mg kg-1.
<i>Ash characteristics investigation from co-firing of Calliandra calothyrsus and Gliricidia sepium with a high-sulfur and -iron coal in a drop tube furnace</i>	Putra, H.P., et al., 2024	The results show that the addition of Calliandra and Gliricidia was able to mitigate the slagging risk according to theoretical prediction and Fact Sage modelling.
<i>Investigation of combustion characteristics and ash-related issues of Calliandra calothyrsus and Gliricidia sepium using thermogravimetric analysis and drop tube furnace</i>	Putra, H.P., et al., 2024	<i>C. calothyrsus</i> shows better ash-related issues with less risk in theoretical slagging prediction, more apparent metal surface in the fouling area, and less ash deposit formation.
<i>Design and optimization of biomass power plant</i>	Gebreegziabher et al., 2014	Results of this study show that with proper drying and heat integration, the overall efficiency of a biomass power plant can be significantly improved.
<i>Effects of pretreatment procedure, compositional feature and reaction condition on the devolatilization characteristics of biomass during pyrolysis process: A review</i>	Liu et al., 2025	Effects of Pretreatment Technologies: Appropriate pretreatment of biomass before pyrolysis can significantly enhance the reactivity of the biomass, thereby increasing the potential for improving the quality of biofuels. Physical pretreatments, such as ball milling.
<i>Comprehensive study on morphology, composition, and structure evolutions of different biomass particles with torrefaction and low-temperature carbonization</i>	Shen et al., 2025	The mass loss, heating value, and energy yield was also compared with each biomass and related to the pretreatment temperatures. The changes of the hemicellulose, cellulose, and lignin contents with effects of temperature and biomass type displayed a similar reducing tendency with the analysis of functional group variation.

<i>Gasification of different biomasses in a concurrent fixed bed reactor: Thermodynamics assessment towards its bioenergy potential</i>	Magalhaes et al., 2025	The results showed that biomasses gasification was technically feasible, and the reactors' performance and operation were affected by biomasses' chemical and physical properties. Torrefied biomasses reduced the percentages of CO ₂ (-18.4 %) and H ₂ (-12.1 %) while increasing the CO (+12.7 %) in the gas, contributing positively to the rise in calorific value.
<i>Experimental investigation of impact of torrefaction on the hydrophobic properties of woody biomass using WDPT and moisture uptake test</i>	Pradeep et al., 2024	This enhancement in hydrophobicity is critical for increasing the HHV of the biomass fuel, indicating that torrefied biomass can be effectively used for various applications.

From Table 1, it can be seen that the planting of Calliandra can be carried out in print media. The Calliandra process becomes biochar, which can be done in several ways with the torrefaction process and can be developed with various technologies currently being developed. One is effective in planting 4 × 2 m a distance or 2.500 trees/ha and can grow in Indonesia in seedlings or cuttings. Then, the efficiency of biomass electricity generation can be increased by proper drying.

Calliandra calothyrsus showed better ash-related issues with lower risk in theoretical slagging prediction. Impact of Pretreatment Technology: Proper biomass pretreatment before pyrolysis, such as ball milling, can significantly improve biomass reactivity. This increase in hydrophobicity is essential to increase the HHV (Higher Heating Value) (biomass fuel), indicating that torrefied biomass can be effectively used for various applications.

Here is some biomass Calliandra processing technology in producing energy

3.1. Power Plant Using Calliandra

3.1.1. Calliandra

Marga Calliandra is one of the Leguminosae tribes, Mimosoideae children, and Ingae groups. Calliandra calothyrsus is a branched small tree that grows to a maximum height of 12 m and a maximum stem diameter of 20 cm. The skin of the stem is red or gray, covered by small lenticels, and pale in oval shape (Prasety et al, 2018). We describe Calliandra hispidulocarpa (Fabaceae), a new species from the Sierra de Manantlán, southwestern Jalisco, Mexico. Specimens of the new species had been confused with the allopatric *C. longipedicellata*, a hypothetically closely related species restricted to a contiguous mountain range (Hernandes, 2024). The texture of Calliandra is quite dense, easy to dry, and flammable, it has a type of weight between 0,5g/cm³ and 0.8 g/cm³ and can produce heat of 4,200 kcal/kg so that it is ideal for firewood or charcoal (Ningtyas et al., 2015).

Calliandra nodules have anatomy that is typical of mimosoid nodules regardless of the microsymbiont type. The rhizobia symbionts differed according to the geographical origin of the species, i.e. Alphaproteobacteria (Rhizobium) were the exclusive symbionts from North-Central America, Betaproteobacteria (Paraburkholderia) from Eastern Brazil, and a mixture of β (Zilli et al., 2021).

The species *Calliandra umbellifera* has abundant saponins in its composition. It is a glycoside that acts in defense against insects and pathogens. Due to these properties, saponins have been described to have antibacterial, antifungal, antiparasitic, anti-inflammatory, and antiviral activity (Costa et al., 2024). The *Calliandra*-like Co_3O_4 particles exhibit satisfied electrochemical performance with high specific capacities and good rate capabilities, exceptionally superior cycling stability when used as anode active materials in lithium-ion batteries, which release an initial discharge capacity of $1139.42 \text{ mA h g}^{-1}$ at 200 mA g^{-1} , and maintain a reversible capacity of $734.64 \text{ mA h g}^{-1}$ after 500 cycles (Liang, 2018). In addition, *Calliandra* is also used as bee feed to control erosion, landslides, and reeds. Recently, a biomass gasification power plant (BGPP) has been expanding *Calliandra* plantations because of *Calliandra*'s high heating value. Since the byproduct of BGPP is biochar, it is widely known for helping CO_2 mitigation (Kosasih et al., 2021).

3.1.2. Biomass Power Plant

There are three types of conferring PLTU in Indonesia, namely 43 types of PC (Pulverized Coal) with a total capacity of 15,620 MW, which requires a mixture of 5% biomass or equivalent to 10,207.20 tons per day. Both 38 types of CFB (Circulating Fluidized Bed) have a total capacity of 2,435 MW, needing 5% biomass or equivalent to 2,175.60 tons per day. The three 23 types of STOKERS with a capacity of 220 MW using 100% biomass or equivalent 5,088 tons per day (Cakbentra, 2021)

3.2. Biochar Processing of *Calliandra*

Calliandra can be used as cofiring material in biochar form. Biochar is a densely rich carbon conversion of organic waste (biomass agriculture) through imperfect burning or limited oxygen supply.

The biomass feedstock is usually subjected to physical pre-treatment procedures such as crushing, screening, drying, and washing the kind of feedstock and process operating parameters, such as temperature, solid residence time, and particle size, determine the properties of the biochar and its surface characteristic (Yashavi, 2025). Biochar is produced through pyrolysis energy conversion, essentially burning biomass without oxygen (Forieka, 2023)

CONCLUSION

Based on the data obtained from the literature review, *Calliandra* is a genius of a group of plants that bear

fruit (legumes), which can be used in many ways. Not only as livestock feed, it turns out that Calliandra can be used as cofiring fuel and can produce heat of 4,200 kcal/kg, so the ideal Calliandra is for firewood or charcoal. The optimal composition of biomass pellets, as recorded by the MOGA-ANN hybrid technique, was 37.71, 20.00, and 41.29 g for paddy straw, sawdust, and binder, respectively, yielding a CV (calory value) of 3745 Cal/g (Ali et al., 2023). Then, Calorific values of *Grevillea robusta*, *Arundinaria alpina*, *Eucalyptus globulus*, *Azadirachta indica*, *Gliricidia sepium*, *Adansonia digitata* L., *Cyprus*, and *Acacia auriculiformis* wood fuels. The calorific values of the solid fuels ranged between 13.13 ± 0.11 MJ/kg and 32.71 ± 0.19 MJ/kg (Bosire et al, 2023).

Based on this, the calorific value of Calliandra is 4,200 kcal/kg greater than the hybrid technique for paddy straw, sawdust, and binder, respectively, yielding a CV (calory value) of 3745 kcal/kg and more petite than wood fuels with calorific values is 13,130 kcal/kg. Calliandra is suitable for internal fuel because its calorific value is relatively high, and the planting process is more straightforward than wood. Calliandra can cofire in biochar through pyrolysis (biomass is without oxygen).

REFERENCES

- Ali. Arshad, Meena. Kumari, and R. Kumar. Sahdev, "Optimal composition of biomass pellet for enhancing calorific value using MOGA-ANN: a mixture of paddy straw, sawdust, cow dung, and paper pulp," *Biomass Convers Biorefin*, Jun. 2023.
- Bosire, J. O. Osano, A. M. and Oyaro, N. "Characterization of Selected Solid Fuels and Their Calorific Values in Kenya: A Case Study of Bomet, Narok, Taita-Taveta, and Mombasa Counties," *Chemistry Africa*, vol. 7, no. 2024, pp. 1509–1522, Nov. 2023.
- Cakbentra, "Wood Chip, Wood Pellet, dan Wood Briquette dari Kebun Energi untuk Pasar Lokal Bagian 2," inovasi biomasa. 2021.
- Costa M. S. *et al.*, "UPLC–QTOF–MS/MS analysis of saponin-enriched fractions from Calliandra umbellifera Benth and evaluation of antibacterial activity against multidrug-resistant bacteria," *Phytochem Lett*, vol. 59, pp. 64–68, Feb. 2024, doi: 10.1016/j.phytol.2023.11.002.
- Dida, S, Kurniaty, R. Putri, K. P. and Suita, E. "Kaliandra (*calliandra callothyrsus*) as a timber for energy: In a point of view of seeds and seedlings procurement," in *Energy Procedia*, Elsevier Ltd, 2014, pp. 62–70. doi: 10.1016/j.egypro.2014.01.197.
- Ali. Arshad, Meena. Kumari, and R. Kumar. Sahdev, "Optimal composition of biomass pellet

- Fikri Maulana *et al.*, “Potensi Kaliandra (*Calliandra Calothyrsus*) dan Gamal (*Gliricidia Sp.*) di Daerah Istimewa Yogyakarta Untuk Pengembangan Pelet Kayu,” vol. 1, 2021.
- Forieka. S. Tania, “Biochar: Mengenal Lebih Dekat Arang dari Bahan Baku Biomassa,” zona EBT, 2023.
- Gebreegziabher, T. Oyedun, A. O. Luk, H. T. Lam, T. Y. G, Zhang, . Y. and Hui, C. W. “Design and optimization of biomass power plant,” *Chemical Engineering Research and Design*, vol. 92, no. 8, pp. 1412–1427, 2014, doi: 10.1016/j.cherd.2014.04.013.
- Green B. N., C. D. Johnson, and A. Adams, “Writing narrative literature reviews for peer reviewed journals: secrets of the trade,” vol. 5, no. 3, pp. 101–17, 2006.
- Hernández, H. M. and Gómez-Hinostrosa, C. “*Calliandra hispidulocarpa* (Fabaceae), a new species from Jalisco, Mexico, with an amended description of *C. longipedicellata*,” *Brittonia*, 2024, doi: 10.1007/s12228-024-09806-x.
- Kosasih, I. Wu, K. T. Sipayung, H. N. and Chen, C “Biochar application in *Calliandra calothyrsus* plantation management,” *Agroforest Syst*, vol. 96, no. 2022, pp. 115–127, Oct. 2021.
- Kurniaty, R. Bustomi, S. and Widyati, E. “Penggunaan Rhizobium dan Mikoriza dalam Pertumbuhan Bibit Kaliandra (*Calliandra calothyrsus*),” Dec. 2013.
- Liang, M. Zhao, M. Wang, H. Wang, F. and Song, X. “Excellent cycling stabilities of a novel calliandra-like Co₃O₄ acted as anode materials for the lithium-ion battery,” *J Energy Storage*, vol. 17, pp. 311–317, Jun. 2018, doi: 10.1016/j.est.2018.03.017.
- Liu, N *et al.*, “Effects of pretreatment procedure, compositional feature and reaction condition on the devolatilization characteristics of biomass during pyrolysis process: A review,” *Journal of the Energy Institute*, vol. 118, p. 101943, Feb. 2025, doi: 10.1016/j.joei.2024.101943.
- Maria, M., Diana W, “Pelatihan Pembuatan Biochar dari Limbah Sekam Padi Menggunakan Metode Retort Kiln (Training on Biochar Production from Rice Husk Using Retort Kiln Method),” *Agrokreatif*, vol. 3, no. 2, 2017.
- Mauritio, P. “Pengaruh Variasi Suhu Torefaksi Terhadap Perubahan Warna Dan Sifat Fisik Pelet Kaliandra (*Calliandra*

- calothyrsus),” *Jurnal Ilmiah Kehutanan*, vol. 10, no. 5, 2020.
- Magalhães M. A. ., “Gasification of different biomasses in a concurrent fixed bed reactor: Thermodynamics assessment towards its bioenergy potential,” *Biomass Bioenergy*, vol. 193, p. 107530, Feb. 2025, doi: 10.1016/j.biombioe.2024.107530.
- Mirko Barz, “Biomass Technology for Electricity Generation in Community,” 2008.
- Ningtyas, W. Nuraini, Y. and Handayanto, E. “View of Pengaruh Kombinasi Biochar dan Sisa Tanaman Legum Terhadap Ketersediaan N dan P Tanah Serta Emisi CO₂ Pada Lahan Kering,” *Jurnal Tanah dan Sumberdaya Lahan*, Vol. 2, No. 1, pp. 139–146, 2015.
- Nyataa, O. Z., O’Neill, M. K. Doward, P. T. and Keatinge, J. D. H. “Harvesting Strategies for Improved Mixtures of Calliandra and Napier Grass in the Central Kenyan Highlands,” *Journal of Sustainable Agriculture*, vol. 19, no. 3, pp. 77–95, Feb. 2008.
- Prasety, E. *et al.*, “Penanaman Kaliandra Sebagai Kayu Energi dan Hijauan Makanan Ternak Pada Pertanaman Agroforestri Masyarakat Desa Gerbosari, Samigaluh Kulon Progo,” 2018.
- Pradeep, M. Kumar K. Panwar, V. N. L. and Rathore, N. “Experimental investigation of impact of torrefaction on the hydrophobic properties of woody biomass using WDPT and moisture uptake test,” *Energy* 360, vol. 2, p. 100009, Dec. 2024, doi: 10.1016/j.energ.2024.100009.
- Putra, H. P. Kuswa, F. M. Prayoga, M. Z. E. Samudra, H. E. Prabowo, and Hariana, H. “Investigation on combustion characteristics and ash-related issues of *Calliandra calothyrsus* and *Gliricidia sepium* using thermogravimetric analysis and drop tube furnace,” *Bioresour Technol*, vol. 394, p. 130212, Feb. 2024, doi: 10.1016/j.biortech.2023.130212.
- Putra, H. P. Suyanti, S. Kusmiyati, K. “Ash characteristics investigation from co-firing of *Calliandra calothyrsus* and *Gliricidia sepium* with a high-sulfur and -iron coal in drop tube furnace,” *Bioresour Technol*, vol. 413, p. 131537, Dec. 2024, doi: 10.1016/j.biortech.2024.131537.
- Shen, Z. Dong, Z. Zhang, H. Guo, X. and Liu, H. “Comprehensive study on morphology,

- composition, and structure evolutions of different biomass particles with torrefaction and low-temperature carbonization,” *Biomass Bioenergy*, vol. 193, Feb. 2025.
- Siarudin, M and Indrajaya, Y. “Adaptation and productivity of kaliandra for biomass energy source,” in *IOP Conference Series: Earth and Environmental Science*, Institute of Physics Publishing, Feb. 2020. doi: 10.1088/1755-1315/415/1/012016.
- Suita, E. Sudrajat, D. J. and Rina K.P., “Balai Penelitian dan Pengembangan Teknologi Perbenihan Tanaman Hutan Bogor Jl Pakuan Ciheulet Box, Pertumbuhan Bibit Kaliandra Pada Beberapa Komposisi Media Semai Cetak Di Persemaian Dan Lapangan (Growth of Kaliandra Seedling on Different Block Seedling Media Compositions in Nursery and Field),” *Jurnal Penelitian Hutan Tanaman*, vol. 14, no. 1, pp. 73–84, 2017.
- Stewart, J. *Produksi Pemanfaatan kaliandra (Calliandra Calothyrsus)*. Bogor, 2001.
- Yashavi. Trivedi, M. Sharma, Mishra R. K., S. Abhishek, and J. Joshi, “Biochar potential for pollutant removal during wastewater treatment: A comprehensive review of separation mechanisms, technological integration, and process analysis,” *Desalination*, Jan. 2025.
- Zilli, J. É. Moraes Carvalho, C. P. Matos Macedo, A.V ., “Nodulation of the neotropical genus *Calliandra* by alpha or betaproteobacterial symbionts depends on the biogeographical origins of the host species,” *Brazilian journal of microbiology*, vol. 52, pp. 2153–2168, Jul. 2021.