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# Growth Performance of *Vitex parviflora* Juss. and *Swietenia macrophylla* King in an Abandoned Mining Area at Barangay Maibu, Butuan City, Philippines

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## ABSTRACT

This study evaluated the growth performance of *V. parviflora* and *S. macrophylla* planted in an abandoned small-scale mining site in Barangay Maibu, Butuan City, Philippines. This study employed a randomized complete block design (RCBD), with growth parameters including height increment, stem diameter increment, and the number of leaves of the seedlings measured over a five-month period. Soil analysis revealed acidic conditions (pH 5.11), low organic matter levels, and nitrogen and phosphorus. Results showed that *S. macrophylla* exhibited greater height growth (3.96 cm) and stem diameter increase (0.78 cm) compared to *V. parviflora* (0.72 cm and 0.072 cm, respectively). The number of leaves also increased more in *S. macrophylla* (10) than in *V. parviflora* (5). Among the parameters measured, only the height growth showed a statistically significant difference between the two species. In contrast, the differences in stem diameter and number of leaves were not statistically significant. *S. macrophylla* demonstrated better adaptability and potential for rehabilitating degraded mining sites compared to the other species. However, it is recommended that future studies lengthen the duration to evaluate seasonal fluctuations, long-term growth performance, and possible soil amendment techniques to improve site rehabilitation and forest restoration outcomes.

## 1. Introduction

In the Philippines, mining has been a significant economic activity for generations. Historical mining operations have resulted in numerous abandoned mine sites due to the lack of environmental regulations until recently (Samaniego et al. 2020). Difficult situations arise when locations—active and abandoned mine sites—can be categorized as “devastated landscapes”, where they can no longer auto-regenerate promptly; only anthropogenic repair can restore them (Favas et al. 2018). Rehabilitation is crucial for restoring the ecological integrity of disturbed mined lands (Varela et al. 2019). Thus, reforestation of mined-out regions is essential to restoring the ecosystem to its pre-mining environment.

Native species are recommended for rehabilitating mined-out areas, as they are well-adapted to local conditions and support greater biodiversity (Rathfon et al. 2018; Singh 2024). Studies have shown that native plants exhibit higher survival rates, biomass, and net primary production on coal mine spoils (Singh and Kumar, 2022), and promote greater floristic diversity and natural

regeneration in revegetated mining areas (De Jesus et al. 2016). Native trees are essential to the web of life (Carig 2020), particularly in reforestation and greening initiatives aimed at restoring forest landscapes and biodiversity (Engay-Gutierrez et al. 2023). Additionally, through the Department of Environment and Natural Resources (DENR), the government promotes the use of high-quality planting materials in its afforestation activities to promote biodiversity conservation (Department of Environment and Natural Resources 2010).

*Vitex parviflora* is a tropical tree native to the Philippines and Indonesia (USDA-ARS 2020; Useful Tropical Plants 2020). This species is protected in the Philippines due to over-exploitation in some areas of its natural habitat, which is attributed to the high value placed on the wood (De Kok 2020). It is also regarded as the flagship species in Bohol due to its hardness and durability (Lomosbog and Gamil 2015). It can grow in all soil types, from rich sandy loam to calcareous limestone, but prefers dry, shallow, extremely well-drained limestone soils (Useful Tropical Plants 2020). Their fruits are consumed and spread by birds (Gonzales et al. 2009). In the Philippines, natural plants like *V. parviflora* are being utilized to restore damaged habitats and provide local communities with a steady source of income (Rain Forest Restoration Initiative 2020). Another species, *Swietenia macrophylla* King, is one of the most valuable timber species in the world (Gilbero et al., 2019) and has numerous reports on its medicinal uses (Duan et al., 2022; Mahendra et al., 2021; Masdar et al., 2022; Pinto et al., 2021; Shiming et al., 2021). This species has been utilized in afforestation initiatives (Karthikeyan 2020), and biochar derived from its flower receptacles may be applied as a soil amendment to enhance soil fertility (Villegas-Pangga 2020). This species also has a high capacity for survival and a dense canopy, which has been shown to attract insects and birds that can disperse plant seeds naturally in mined-out areas (Varela et al. 2017).

The small-scale mining area in Barangay Maibu, Butuan City, has been abandoned for several years following the cessation of the traditional sluice-based gold mining. This technique, which includes diverting water through foam-lined sluices and manually collecting debris, has contributed to the site's unsettled state. Since the government forbade mining activities within the area, the land has remained undeveloped and is now overgrown with some grasses. This condition presents both a challenge and an opportunity for reforestation.

This study tried to evaluate the growth performance of *V. parviflora* and *S. macrophylla* in the abandoned mining area. Although several studies have explored the growth and biomass accumulation of tropical tree species in plantation or natural forest settings, limited research has focused on their performance under post-mining conditions—particularly within the Philippine context. The difference of this study lies in its comparative assessment of a native (*V. parviflora*) and an introduced (*S. macrophylla*) species under degraded soil conditions, using key growth parameters such as height increment, stem diameter increment, and leaf production to gauge early growth success and adaptive potential. This study also assessed the area's soil conditions to provide recommendations and contributions to reforestation and environmental rehabilitation practices.

## 2. Materials and Methods

### *2.1. Study Site*

The study was conducted at an abandoned mining site in Barangay Maibu, Butuan City, Philippines, situated at 8°50'42.24"N, 125°35'48.22"E (**Fig. 1)**. The site, which is degraded and

partially covered in grass, has been abandoned for several years. Its elevation is 159.5 meters above sea level, and its annual precipitation and humidity are 81.27 mm and 82.55%, respectively (Weather and Climate 2024). Based on Corona's modified climate classification, the area belongs to Climatic Type II, characterized by a minimum monthly rainfall from March to May. The Barangay Maibu has a total land area of 7,693 km$^2$ with a population of 1,580 as determined by the 2015 census, which represents 0.38% of the total population of Butuan City (City Population 2020).

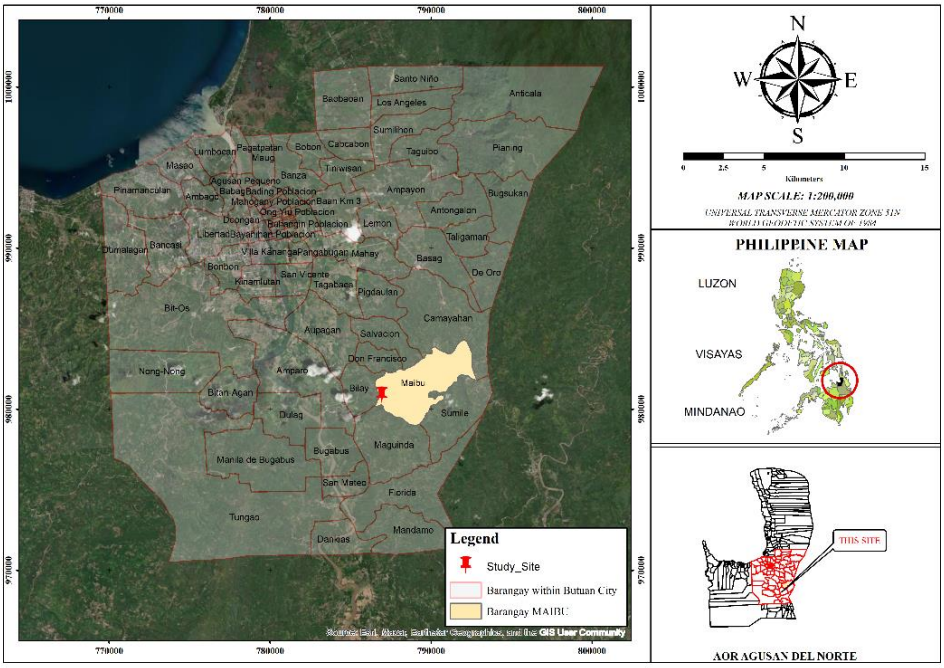


**Fig. 1.** Location of the study.

### *2.2. Research design*

The study followed a randomized complete block design (RCBD) to evaluate the performance of *V. parviflora* and *S. macrophylla* under field conditions. The experiment consisted of four blocks, each containing two plots for the treatments represented by *V. parviflora* and *S. macrophylla* species. Each treatment was randomly assigned to one plot within each block. The design includes four replications of each treatment across the blocks, providing sufficient data for robust statistical analysis.

### *2.3. Seedlings Preparation*

The seedlings of *V. parviflora* and S. *macrophylla* were obtained from the DENR PENRO (Department of Environment and Natural Resources Provincial Environment and Natural Resources Office) in Agusan del Norte, specifically from Barangay Tiniwisan, Butuan City. We specifically requested seedlings of uniform height (15–20 cm) and age (3 months) to ensure consistency in growth performance evaluation. The *V. parviflora* was regarded as treatment one, and *S. macrophylla* as treatment two. Ten sample seedlings were used for each of the four replications of each treatment, 40 seedlings per treatment. A total of 80 individual seedlings from both treatments were included in the study. The seedlings were transplanted into the assigned spot, keeping a two-meter distance between blocks and a one-meter distance between the seedlings.

### *2.4. Data Gathering Procedure*

Before transplanting, the researcher took initial measurements of the *V. parviflora* and *S. macrophylla* seedlings, including stem diameter using a tree caliper, number of leaves, and height using a measuring tape. After five months of transplanting, additional data on stem diameter, leaf number, and height were collected to evaluate the species' growth performance. The researchers also collected soil samples to analyze the soil type, pH, organic matter, and nutrients, including nitrogen (N), phosphorus (P), and potassium (K). Samples were taken using an auger in a zigzag pattern across the plots. The soil was air-dried in a warm, dry location. Once dried, they were submitted to the Department of Agriculture Regional Soil Laboratory in Barangay Taguibo, Butuan City, for analysis.

### *2.5.Data Analysis*

The T-test was used to analyze the data and determine how *V. parviflora* and *S. macrophylla* differed in terms of growth performance indicators. The means of these two groups were compared using the T-test to determine if the observed differences were statistically significant. Normality and homogeneity of variance tests were performed on the data before the t-test. Tables were used to summarize the results, and graphs were used for a more accurate interpretation of the data. A 5% confidence level was used to establish statistical significance, offering reliable information about the development and performance of the seedlings in the abandoned mining site.

## 3. Results and Discussion

### *3.1. Soil Physicochemical Properties*

**Table 1** shows the analysis results of the soil samples from the area. The soil proved to be acidic, with a pH level of 5.11 and a low organic matter content. The soil also has low nitrogen and phosphorus content with moderately sufficient potassium. Given that the area was slightly sloping, nutrients could also have been washed away in soil particles by surface runoff. This is consistent with research demonstrating that mining activities raise soil pH while depleting organic carbon, phosphorus, potassium, and nitrogen (Ahirwal and Maiti 2016; Shrestha and Lal 2011). Unlike undisturbed soils, mined-out soils typically exhibit distinct physical characteristics, lower organic matter content, and higher acidity (Essandoh et al. 2021; Okoh and Zakpaa 2024; Ralte 2017; Zhang et al. 2016). According to Zhang et al. (2016), reclamation initiatives, especially revegetation, can increase the amount of organic carbon in the soil and the infiltration rate. Land cover affects infiltration rate and soil erodibility (Maro'ah et al. 2025). Overall, the soil's qualities are significantly altered by mining, necessitating careful management and reclamation techniques.

**Table 1.** Soil analysis Data

| Texture | pH | % O.M. | N (ppm) | P (ppm) | K (ppm) |
|---|---|---|---|---|---|
| **Heavy** | 5.11 (SA) | 0.9 (L) | 0.045 (L) | 2 (L) | 56 (MS) |

Notes: (L) low, (MS) moderately sufficient, (SA) strongly acidic.

### *3.2. Survival Rate and Growth Performance of the two Species*

After five months of transplanting, both *V. parviflora* and *S. macrophylla* demonstrated a high survival rate of 92.5% in the abandoned mining site. Out of 40 seedlings sampled per species, 37 survived for each species. This suggests that both species can be established in a relatively short time, despite the acidic and nutrient-poor soil conditions at the site.

Regarding growth performance, the findings indicated that *S. macrophylla* exhibited a significantly higher height increment (3.96 cm) compared to *V. parviflora* (0.72 cm), suggesting better adaptation to nutrient-poor, acidic soils. Research indicates that *S. macrophylla* can flourish in alkaline, clayey soils and acidic, sandy soils, retaining comparable potassium and nitrogen levels in the leaves despite environmental variations (Medina et al. 2014). Furthermore, due to its effective light-capture strategy (Goncalves et al. 2012), characterized by broad leaves that promote vertical growth, it exhibited rapid height increase. As illustrated in **Fig. 2**, *S. macrophylla* gathered a larger value of 0.78 cm for the increment in stem diameter, while *V. parviflora* with 0.072 cm.

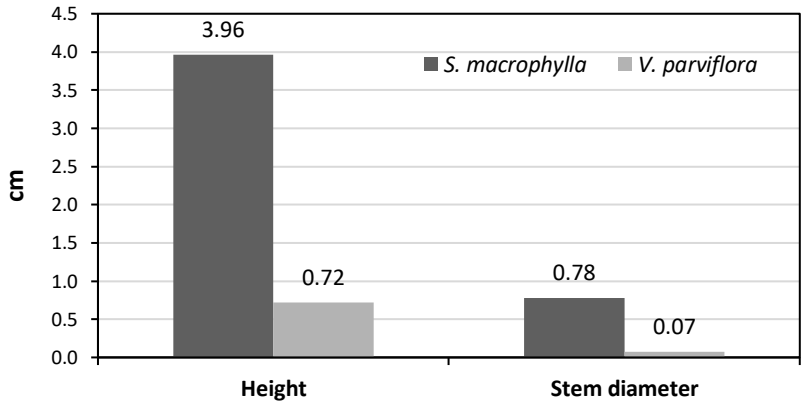


**Fig. 1.** Height and stem diameter increments of *S. macrophylla* and *V. parviflora*.

The number of leaves was also higher, with *S. macrophylla* having 10 additional leaves, while *V. parviflora* has half of the former, which is 5 (**Fig. 3**). *S. macrophylla's* increased stem diameter may be attributed to its active root development, strong cambial activity, and effective utilization of light and nutrients, all of which contribute to its rapid biomass accumulation (Goncalves et al. 2012). A species' ability to photosynthesize and general health can also be determined by how many leaves it produces (Poorter et al. 2011). A larger leaf count in *S. macrophylla* indicates a better capacity to absorb light, facilitating quicker biomass production and carbon uptake. These physiological characteristics complement its rapid growth in diameter and height.

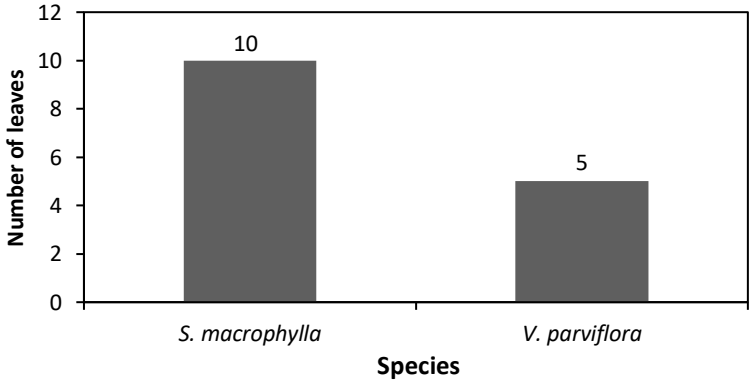


**Fig. 3.** Number of leaves of S. *macrophylla* and *V. parviflora*.

Statistically, only the height increment showed significant differences between the two species, as shown in **Table 2**. Stem diameter increment and number of leaves showed no significant differences between the two species. These findings align with previous studies, which indicate that *S. macrophylla* thrives in marginal soils due to its ability to improve soil structure and retain nutrients (Mindawati and Megawati 2013; Wasis and Andika 2017). It also has high success rates of reforestation activities in other mining areas (Pratomo et al. 2018). Conversely, while *V. parviflora* displayed slower growth, its role as a native species contributes to long-term ecosystem resilience and biodiversity conservation (Carig 2020; Singh 2024).

**Table 2.** Morphological Growth Comparison of S. *macrophylla* and *V. parviflora*

| Growth Performance | p-value | Remarks |
|---|---|---|
| Height | <0.001 | Highly significant |
| Stem diameter | 0.776 | Not significant |
| Number of Leaves | 0.961 | Not significant |

The findings suggest that *S. macrophylla*, due to its pronounced morphological growth, particularly in height, may possess a competitive edge over other flora in environments where rapid vertical development is crucial for light acquisition. It can effectively outcompete *V. parviflora* for sunlight in mixed-species plantations, given its superior height. If both species are cultivated in conjunction, this could lead to the dominance of *S. macrophylla*, which, in turn, might decrease biodiversity if not appropriately managed. Its accelerated height growth suggests that, among the two species under examination, *S. macrophylla* is better suited for reforestation where soil stability, invasive species control, and ecosystem restoration hinge on rapid canopy development.

However, the absence of notable variations in stem diameter and leaf yield implies that *V. parviflora* may still be resilient and adaptable within its ecosystem. *V. parviflora* is esteemed for its high-quality, durable wood, which retains its value in specialized markets (Caraig 2023). Its comparatively slower growth indicates it is likely more suitable for resilience and long-term stability initiatives in less disturbed areas. Moreover, it may indicate adaptations to specific ecological niches, highlighting the importance of preserving local species in reforestation initiatives. As a native species, *V. parviflora* plays a crucial role in maintaining ecological balance. It is recommended for bioremediation of areas contaminated with copper (Tulod et al. 2012).

These results could inform species selection for reforestation and afforestation programs, emphasizing each species' growth requirements and ecological roles. Although some may overlook this, the implications are significant. Future studies should investigate whether adding organic amendments, such as biochar from S. *macrophylla's* flower receptacles, can enhance *V. parviflora's* growth (Villegas-Pangga 2020). Furthermore, it has been demonstrated that applying compost and mycorrhizal inoculation improves nitrogen uptake in degraded soils (Ahirwal and Maiti 2016; Ali et al. 2019; Castañeto 2001; Hussain et al. 2018; Mindawati and Megawati 2013; Nayak and Santhoshkumar 2020; Nigussie et al. 2021; Wasis and Sandrasari 2011).

## 4. Conclusions

The abandoned mining site in Barangay Maibu exhibited strongly acidic soil with low levels of organic matter, nitrogen, and phosphorus—conditions typical of post-mining deterioration,

emphasizing the importance of proper species selection. The results showed that *S. macrophylla* was more adapted to the area's acidic and nutrient-poor soil conditions than *V. parviflora* in terms of height, stem diameter, and leaf count. However, *V. parviflora* remains valuable because of its ecological role and high-quality timber. These findings emphasize the importance of species selection in reforestation initiatives, suggesting *S. macrophylla* for site stabilization and rapid canopy formation while promoting further studies on soil amendments to enhance the growth potential of native species, such as *V. parviflora*. Future research should extend the observation period beyond five months to provide a more comprehensive understanding of these species' long-term growth trends and survival rates. A more extended study period will enable a more accurate evaluation of seasonal growth changes, adaptation to environmental conditions, and overall success in rehabilitating degraded lands.

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**Author Contributions**

S.L.D.G.: Conceptualization, Methodology, Data Analysis, Supervision, Writing – Original Draft Preparation, Review and Editing; L.C.B.: Conceptualization, Methodology, Data Curation, Writing – Original Draft Preparation; M.C.M.: Conceptualization, Methodology, Data Curation, Writing – Original Draft Preparation; R.C.Q.: Conceptualization, Methodology, Data Curation, Writing – Original Draft Preparation.

**Conflict of Interest**

The authors declare no conflict of interest.

**Declaration of Generative AI and AI-Assisted Technologies in the Manuscript Preparation**

During the preparation of this work, the authors used Quillbot.com – a paraphrasing tool to smartly blend other research into this article and avoid plagiarism. After using this tool/service, the authors reviewed and edited the content as needed and took full responsibility for the publication's content.

## References

Ahirwal, J., and Maiti, S. K. 2016. Assessment of Soil Properties of Different Land Uses Generated Due to Surface Coal Mining Activities in Tropical Sal (*Shorea robusta*) Forest, India. *CATENA* 140: 155–163. DOI: 10.1016/j.catena.2016.01.028

Ali, F. S., Saad, O. A. O., and Maisar, Y. S. 2019. Response Of Wheat and Maize Plants to Application of Compost and Inoculation with Vesicular Arbuscular Mycorrhizae. *Minia Journal of Agricultural Research and Development* 39(1): 161–174. DOI: 10.21608/mjard.2019.226585

Castañeto, Y. T. 2001. Growth Response of Molave (*Vitex parviflora* Juss.) Seedlings to Biocore and Mykovam. *Philippine Journal of Science* 130(2): 97–102.

Caraig, R. V. 2023. A Glimpse to Botanical Garden: Case Study in the Environment and Ecological Niche of Molave Tree. *BOHR International Journal of Civil Engineering and Environmental Science* 1(2): 62–64. DOI: 10.54646/bijcees.007

Carig, E. T. 2020. *Guidebook on Native Trees within the Quirino Forest Landscape*. St. Andrew Publishing House. Bulacan, Philippines.

City Population. 2020. *Philippines: Butuan City*. <https://www.citypopulation.de> (Jan. 30, 2025)

De Jesus, E. N., Santos, T. S. D., Ribeiro, G. T., Orge, M. D. R., Amorim, V. O., and Batista, R. C. R. C. 2016. Regeneração Natural de Espécies Vegetais em Jazidas Revegetadas. *Floresta E Ambiente* 23(2): 191–200. DOI: 10.1590/2179-8087.115914

Department of Environment and Natural Resources. *DENR Administrative Order No. 11 Series of 2010. Establishing the Revised Regulations Governing Forest Tree Seed and Seedling Production, Collection and Disposition*. Department of Environment and Natural Resources. Philippines.

Duan, J. Y., Zhang, F., Lu, M. Y., Deng, W. H., Zhai, Y. T., Zhao, Y. Q., He, L. L., Bai, Z. H., Wang, Y. J., and Zhang, C. P. 2022. Swietenine and Swietenolide from *Swietenia macrophylla* King Improve Insulin Secretion and Attenuate Apoptosis in $H_2O_2$ Induced Ins-1 cells. *Environmental Toxicology* 37(11): 2780–2792.

Engay-Gutierrez, K. G., Espaldon, M. V. O., Sobremisana, M. J., Macandog, D. M., and Tiburan, C. L. 2023. The Sustainability of Native Trees in the Greening Initiatives of the Philippines. *Up Los Baños Journal* 21(2): 63–104.

Essandoh, P. K., Takase, M, and Bryant, I. M. 2021. Impact of Small-Scale Mining Activities on Physicochemical Properties of Soils in Dunkwa East Municipality of Ghana. *The Scientific World Journal* 9915117 DOI: 10.1155/2021/9915117

Favas, P. J., Martino, L. E., and Prasad, M. N. 2018. *Abandoned Mine Land Reclamation—Challenges and Opportunities (Holistic Approach)*. Elsevier. DOI: 10.1016/b978-0-12-812986-9.00001-4

Gilbero, D. M., Abasolo, W. P., Matsuo-Ueda, M., and Yamamoto, H. 2019. Surface Growth Stress and Wood Properties of 8-year-old Planted Big-Leaf Mahogany (*Swietenia macrophylla* King) from Different Landrace Provenances and Trial Sites in the Philippines. *Journal of Wood Science* 65(1): 35. DOI: 10.1186/s10086-019-1814-4

Gonçalves, J. F., Silva, C. G., Justino, G. C., and Júnior, A. D. 2012. Effect of Light Environment on Growth of Young Plants of Mahogany (*Swietenia macrophylla* King). *Scientia Forestalis* 40: 337–344.

Gonzales, R. S., Ingle, N. R., Lagunzad, D. A., and Nakashizuka, T. 2009. Seed Dispersal by Birds and Bats in Lowland Philippine Forest Successional Area. *Biotropica* 41(4) 452–458. DOI: 10.1111/j.1744-7429.2009.00501.x

Hussain, S., Sharif, M., Ahmad, W., Khan, F., and Nihar, H. 2018. Soil and Plants Nutrient Status and Wheat Growth after Mycorrhiza Inoculation With and Without Vermicompost. *Journal of Plant Nutrition* 41: 1534–1546.

Karthikeyan, A. 2020. Afforestation in Barren Laterite Lands with *Swietenia macrophylla* G. King and Plant Growth Promoting Microbes: Afforestation in Laterite Lands. *REFORESTA* 9: 54–65. DOI: 10.21750/REFOR.9.07.81

De Kok, R. 2020. *Vitex Parviflora. The IUCN Red List of Threatened Species*: *e.T33339A67741355*. <https://www.iucnredlist.org/> (Dec. 11, 2024)

Lomosbog, N. T. and Gamil, N. S. 2015. Characterization of Potential Molave (*Vitex parviflora* Juss.) Mother Trees in Lila, Bohol, Philippines. *International Journal of Environmental and Rural Development* 6–2: s16. DOI: 10.32115/ijerd.6.2_11

Mahendra, C. K., Abidin, S. A. Z., Htar, T. T., Chuah, L. H., Khan, S. U., Ming, L. C., Tang, S. Y., Pusparajah, P., and Goh, B. H. 2021. Counteracting the Ramifications of UVB Irradiation and Photoaging with *Swietenia macrophylla* King Seed. *Molecules* 26(7): 2000.

Maro'ah, S., Cahyono, O., Ariyanto, D. P., and Pramudita, T. 2025. Analysis of Alfisol Soil Infiltration Rate on Various Land Cover and Its Effect on Soil Erodibility in Mount Bromo Special Purpose Forest Area, Indonesia. *Jurnal Sylva Lestari* 13(1): 203–217. DOI: 10.23960/jsl.v13i1.993

Masdar, N. D., Uyup, N. H., Zainol, Z. E., Roslani, M. A., Anuar, S. N. S., and Zulkafle, M. A. 2022. The Chemical Properties and Anti-acne Activity Determination of *Swietenia macrophylla* Seed Extracts. *Malaysian Journal of Analytic Sciences* 26(2): 229–240.

Medina, E., Cuevas, E., Lugo, A.E., Terezo, E., Jiménez-Osornio, J., Macario-Mendoza, P.A., and Montañez, P. 2014. Conservative Nutrient Use by Big-Leaf Mahogany (*Swietenia macrophylla* King) Planted under Contrasting Environmental Conditions. *Revista Arvore* 38: 479–488.

Mindawati, N. and Megawati. 2013. Manual Budidaya Mahoni (*S. macrophylla* King) Badan Penelitian dan Pengembangan Kehutanan. Bogor, Indonesia.

Nayak, S., and Santhoshkumar, A.V. 2020. Effect of Arbuscular Mycorrhizal Fungi on The Growth of Mahogany (*Swietenia macrophylla* King.) Seedlings under Nursery Condition. *Indian Journal of Pure and Applied Biosciences* 8(6): 124–129. DOI: 10.18782/2582-2845.8241

Nigussie, A., Haile, W., Agegnehu, G., and Kiflu, A. 2021. Growth, Nitrogen Uptake of Maize (*Zea mays* L.) and Soil Chemical Properties, and Responses to Compost and Nitrogen Rates and Their Mixture on Different Textured Soils: Pot Experiment. *Applied and Environmental Soil Science* 9931763 DOI: 10.1155/2021/9931763

Okoh, P., and Zakpaa, H. 2024. Soil Analysis of a Mined-Out Area at Afiesa, Ghana. *Environmental Technology and Science Journal* 15(1): 105–112. DOI: 10.4314/etsj.v15i1.11

Pinto, L. C., Mesquita, F. P., Barreto, L. H., Souza, P. F. N., Ramos, I. N. F., Pinto, A.V. U., Soares, B. M., da Silva, M. N., Burbano, R. M. R., and Montenegro, R. C. 2021. Anticancer Potential of Limonoids from *Swietenia Macrophylla*: Genotoxic, Antiproliferative and Proapoptotic Effects Towards Human Colorectal Cancer. *Life Sciences* 41(4): 452–458.

Poorter, H., Niklas, K. J., Reich, P. B., Oleksyn, J., Poot, P., and Mommer, L. 2011. Biomass Allocation to Leaves, Stems and Roots: Meta-Analyses of Interspecific Variation and Environmental Control. *New Phytologist* 193(1): 30–50. DOI: 10.1111/j.1469-8137.2011.03952.x

Pratomo, J. A., Banuwa, I. S., and Yuwono, S. B. 2018. Evaluation on the Growth of Reforestation Plants at the Compensated Land for Gold Mining of Natarang Mining Ltd. *Jurnal Sylva Lestari* 6(2): 41. DOI: 10.23960/jsl2641-50

Rain Forest Restoration Initiative. 2020. *Rainforestation Information Portal. Philippines*. <http://www.rainforestation.ph> (Nov. 12, 2024)

Ralte, V. 2017. Effect of Coal Mining on Soil Physico-Chemical Properties of Nokrek Biosphere Reserve of Meghalaya, Northeastern India. *Science Vision* 17(4): 228–237. DOI: 10.33493/scivis.17.04.07

Rathfon, R., Groninger, J., Jacobs, D. F., Burger, J. A., Angel, P. N., and Zipper, C. E. 2018. Tree and Shrub Species Selection for Mine Reclamation in the Midwest Region of USA. *Journal of Environmental Solutions for Oil, Gas, and Mining* 4(1): 31–52. DOI: 10.3992/2377-3545-4.1.31

Samaniego, J., Gibaga, C. R., Tanciongco, A., and Rastrullo, R. 2020. Total Mercury in Soils and Sediments in the Vicinity of Abandoned Mercury Mine Area in Puerto Princesa City, Philippines. *Applied Sciences* 10(13): 4599. DOI: 10.3390/app10134599

Shiming, Z., Mak, K.-K., Balijepalli, M. K., Chakravarthi, S., and Pichika, M. R. 2021. Swietenine Potentiates the Antihyperglycemic and Antioxidant Activity of Metformin in Streptozotocin Induced Diabetic Rats. *Biomedicine and Pharmacotherapy* 139: 111576. DOI: 10.1016/j.biopha.2021.111576

Shrestha, R. K., and Lal, R. 2011. Changes in Physical and Chemical Properties of Soil after Surface Mining and Reclamation. *Geoderma* 161(3–4): 168–176. DOI: 10.1016/j.geoderma.2010.12.015

Singh, S. 2024. Ecological Restoration of Mined Out Areas. *AgriLife* 31–36.

Singh, A. N., and Kumar, A. 2022. Ecological Performances of Exotic and Native Woody Species on Coal Mine Spoil in Indian Dry Tropical Region. *Ecological Engineering* 174: 106470. DOI: 10.1016/j.ecoleng.2021.106470

Tulod, A. M., Castillo, A. S., Carandang, W. M., and Pampolina, N. M. 2012. Growth Performance and Phytoremediation Potential of *Pongamia pinnata* (L.) Pierre, *Samanea saman* (Jacq.) Merr. and *Vitex parviflora* Juss. In Copper-Contaminated Soil Amended with Zeolite and VAM. *Asia Life Sciences* 21(2): 499–522.

USDA-ARS. 2020. *Germplasm Resources Information Network (GRIN)*. <https://npgsweb.ars-grin.gov> (Dec. 11, 2024)

Useful Tropical Plants. 2020. *Useful Tropical Plants Database*. <http://tropical.theferns.info> (Dec. 11, 2024)

Varela, R. P., Cayomo, J. R., Vanzuela, R. A., and Millan, C. R. R. 2019. Plant Species Growing in Lateritic Soil with Ornamental Potential for Mined Land Rehabilitation. *International Journal of Conservation Science* 10(4): 773–780.

Varela, R. P., Garcia, G. A., Garcia, C. M., and Ambal A. M. 2017. Survival and Growth of Plant Species in Agroforestry System for Progressive Rehabilitation of Mined Nickel Sites in Surigao del Norte, Philippines. *Annals of Studies in Science and Humanities* 2(1): 16–25.

Villegas-Pangga, G. 2020. Production and Characterization of Biochars from Slow Pyrolysis of Different Biomass Materials to Evaluate Properties as Soil Amendments. *Philippine Journal of Science* 150(1). DOI: 10.56899/150.01.25

Wasis, B., and Andika, A. 2017. Growth Response of Mahagony Seedling (*Swietenia macrophylla* King.) to Addition of Coconut Shell Charcoal and Compost on Ex-Sand Mining Site of West Java Province in Indonesia. *Agriculture and Environmental Science* 2(3): 238–243.

Wasis, B., and Sandrasari, A. 2011. Pengaruh Pemberian Pupuk Kompos terhadap Pertumbuhan Semai Mahoni (*Swietenia macrophylla* King.) pada Media Tanah Bekas Tambang Emas (Tailing). *Jurnal Silvikultur Tropika.*

Weather and Climate. 2024. *The Global Historical Weather and Climate Data*. <https://weatherandclimate.com/ > (Nov. 12, 2024)

Zhang, P., Cui, Y., Zhang, Y., Jia, J., Wang, X., and Zhang, X. 2016. Changes in Soil Physical and Chemical Properties following Surface Mining and Reclamation. *Soil Science Society of America Journal* 80: 1476–1485.