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Ethnobotanical knowledge of Dayak Ngaju in utilizing plant species to locate gold mining in Sei Riang Village, Central Kalimantan, Indonesia

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Abstract. *Sunariyati S, Decenly, Purnama AR, Agnestisia R. 2023. Ethnobotanical knowledge of Dayak Ngaju in utilizing plant species to locate gold mining in Sei Riang Village, Central Kalimantan, Indonesia. Biodiversitas 24: 4145-4150.* Indonesia is one of the richest countries in flora and cultural diversity. The strong relationship between the culture and plant diversity has developed ethnobotanical knowledge of the indigenous community, including the knowledge of the Dayak Ngaju Tribe in utilizing plant species as gold indicators. Therefore, this study aimed to inventory and identify the plant species used as gold indicators by Dayak Ngaju in Sei Riang Village, Gunung Mas District, Central Kalimantan, Indonesia using ethnobotanical study and then empirically assess the gold content in the identified plants using laboratory analysis. Ethnobotanical information was collected through in-depth interviews with 25 informants and analyzed with the Informant Agreement Ratio (IAR). Plants mentioned as gold indicators were then identified in the field. The samples of the plants were then examined by atomic absorption spectroscopy to determine gold (Aurum; Au) contents in their root, stem, and leave tissues. The data was analyzed using SPSS 25 with the Parametric Pearson Correlation test to determine the correlation and significance level of Au contents found in the plant tissues and soil. Based on the interview results, the gold miners believed that several plant species could be utilized to indicate gold's presence in the mining area, as indicated by the value of IAR of 0.540, suggesting that 54% of the informants agreed to use the plants as the gold indicator. Two plant species were identified as gold indicators: *kasuhui* (*Dipterocarpus* sp.) and *hara* (*Ficus racemosa* L.). Significant positive correlations were also exhibited between Au contents in the *kasuhui* stem and the *hara* root and stem and the soils where they grow. This research is expected to promote the ethnobotanical knowledge of the gold miners from the Dayak Ngaju Tribe in selecting scientifically justifiable gold mining areas.

Keywords: *Dipterocarpus*, ethnobotanical knowledge, gold indicator, *Ficus racemosa*, *hara*, *kasuhui*

INTRODUCTION

Ethnobotany is the science that studies the interaction between humans and plants in their culture (Pandey and Tripathi 2017; Pei et al. 2020). In many cases, the study of ethnobotany involves an inventory of plant species with various benefits to humans and examining their interactions with social traditions (Eldeen et al. 2016). Ethnobotany has been widely utilized to explore scientific knowledge on food security, human health, climate change, and biodiversity conservation (Pei et al. 2020). In a rare theme of ethnobotany, Ullah et al. (2019) showcase the application of ethnobotanical knowledge to investigate the plant species utilized as metal indicators in the soil. The biogeochemical study by Ullah et al. (2019) showed that *Silene conoidea* L. from Western Eurasia could uptake and accumulate gold (Aurum; Au) with a high concentration of 303 ppb. This finding expands the potential application of ethnobotany for mineral exploration beyond its common uses.

Indonesia is a country with great cultural and ethnic diversity which provides a huge opportunity to conduct ethnobotanical studies. Over the past 20 years, ethnobotanical researchers have documented various plant species from Indonesia which have been utilized by local people for medicine, condiment, food, traditional ceremonies, and household income (Sunariyati et al. 2017a; Listiani and Abrori 2018; Jadid et al. 2020; Sutrisno et al. 2020; Navia et al. 2021; Susandarini et al. 2021). Among them, unique research by Sunariyati et al. (2017b) conducted an ethnobotanical study for the first time to observe plant species that could potentially be utilized as an indicator of gold metal in Indonesia. The study discovered 11 plant species that are being used as gold indicators by local miners in Central Kapuas, i.e., *Calophyllum hosei* Ridl., *Dillenia excelsa* (Jack) Gilg, *Dipterocarpus crinitus* Dyer, *Agrostistachys sessilifolia* (Kurz) Pax & K.Hoffm., *Tristania obovata* Benn., *Tristaniopsis merguiensis* (Griff.) Paul G.Wilson & J.T.Waterh., *Ganua motleyana* (de Vriese) Pierre ex Dubard, *Swintonia glauca* Engl., *Syzygium zeylanicum* (L) DC, *Combretocarpus rotundatus* (Miq.) Danser, and *Memecylon myrsinoides* Blume. It demonstrates that ethnobotanical research in Indonesia has been developed rapidly and must be continuously improved to ensure the utilization of plant diversity and preserve traditional knowledge in the future.

The tolerance of plants to high metal concentrations in the soil can be divided into three groups, namely: (i) the hyperaccumulator plants that can actively take up metals from the soil and translocate them from the root to shoot, thereby accumulating the metals in their above-ground tissues; (ii) the indicator plants that indicate metal levels in their body to reflect metal levels in the soil; and (iii) the excluder plants which can inhibit metal from entering into their tissues or confine root-to-shoot translocation (Baker 1981; Kutty and Al-Mahaqeri 2016; Lam et al. 2022). Several researchers also pointed out that several criteria can be adopted to determine hyperaccumulator, indicator, and excluder plant species. A plant is classified as a hyperaccumulator when it fulfills criteria, such as: (i) leaf/root quotient (level of metal in the leaf divided by the level of metal in the root) > 1, (ii) extraction coefficient (level of metal in the leaf divided by the level of metal in the soil) > 1, and (iii) higher metal levels which are 10-500 times the levels in normal plants. On the other hand, a plant is considered a metal indicator when the level of metals in the plant tissues is similar to those in the soil. Meanwhile, a plant with leaf/root quotients less than 1 is categorized as an excluder plant (Baker 1981; Kutty and Al-Mahaqeri 2016; Lam et al. 2022).

Gunung Mas District is one of the newly established regencies in the Central Kalimantan Province, Indonesia, with the dominant population of the Dayak Ngaju Tribe. It is an indigenous tribe among other *Dayak* Tribes in Kalimantan and living alongside the rivers of Kahayan, Kapuas, Katingan, and Barito (Karyani 2021). This tribe is very attached to nature and has much knowledge of the benefits of plants from its social and cultural traditions. Sei Riang Village, Gunung Mas District, is known to have high gold potential, and most people work as gold miners. Interestingly, based on anecdotal information, some of them utilized plants as indicators for the presence of gold in mining areas, but the scientific evidence is not yet known. Sheoran et al. (2013) explained that several plants could take gold from the soil and accumulate it in their tissues. Similarly, Sunariyati (2018) stated that plants used as gold indicators can accumulate gold in their tissue. *Helianthus annuus* L. and *Brassica juncea* (L.) Czern. are plants that grow in soil containing gold and can collect it in their tissue (Sheoran et al. 2013; Pisco et al. 2017).

Accordingly, the present study aimed to scientifically investigate the local knowledge of the *Ngaju Dayak* Tribe on plant uses as gold indicators in Sei Riang Village, Gunung Mas District, Central Kalimantan Province. We expected that this study might enrich the scientific understanding of ethnobotany and add a novel understanding of the application of indigenous knowledge for mineral exploration. In the context of mining practices, the obtained information could serve as a source of information for local gold miners, especially for the Dayak Ngaju community in Gunung Mas District, to select gold mining areas by utilizing plants that are considered low at cost and effort as well as environmentally friendly compared to, for example, random drilling method. Nonetheless, we strongly caution that the uses of this study are not for illegal mining practices carried out in prohibited areas that destroy the environment.

MATERIALS AND METHODS

Study area and period

The research was carried out in the forest area of gold mining, Sei Riang Village, Tewah Sub-district, Gunung Mas District, Central Kalimantan Province, Indonesia (Figure 1). The study was conducted from February 2020 to March 2021.

Research procedures

This research was conducted in three stages. The first stage was a qualitative ethnobotany study to explore information from selected informants on the plants utilized as gold indicators. The second stage was the identification of plant species through morphological characterization. The third stage was analyzing the Au contents in plant tissues and soil using atomic absorption spectroscopy. The details of each stage are explained below.

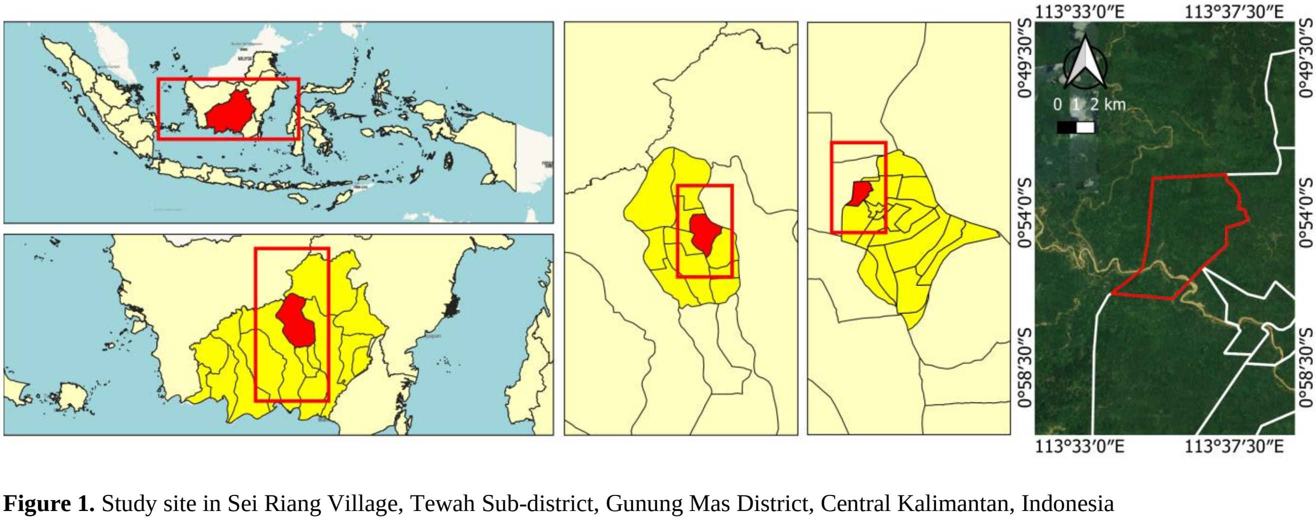

Figure 1. Study site in Sei Riang Village, Tewah Sub-district, Gunung Mas District, Central Kalimantan, Indonesia

Ethnobotanical knowledge analysis

The ethnobotanical information on the uses of plants as gold indicators was collected through participatory observation and in-depth interviews with 25 informants from the Dayak Ngaju Tribe. The informants generally worked as local miners in the gold mining area in Sei Riang Village, aged 18-53 years, with educational backgrounds of elementary and junior high school graduates. The purposive sampling method was adopted in this study (Alexiades 1996). The informants were chosen based on their local knowledge of selecting gold mining locations. They were given a close-ended questionnaire so that the information from each informant could be stated based on their experience and knowledge. Then, the informants who used plants to select gold mining areas were interviewed in-depth. The interview aimed to gather information regarding the plant species they thought to be gold indicators. Based on the information, a floristic survey was then conducted guided by those informants.

Data were analyzed by organizing and systematically compiling the results from questionnaires, interviews, and field notes. The local community knowledge was examined with a descriptive method from interview results. The results were then displayed in pie charts. The obtained information was analyzed through the Informant Agreement Ratio (IAR) calculated as Equation 1 (Alexiades 1996).

$$IAR = (n_a - n_{ra}) / (n_a - 1) \quad [1]$$

Where: n_a represents the number of plant users as gold indicators, n_{ra} represents the number of plants in one type used as gold indicators by interviewed informants. The IAR has a range of values from 0 to 1. The IAR has a value range from 0 to 1. An IAR of 0 indicates that all informants disagree with using plants as gold indicators, while an IAR of 1 indicates that all informants agree with using plants as gold indicators.

Plant identification and soil sampling

As described above, the informants who utilized plants for locating gold mining areas were interviewed in-depth to inform plant species believed to be gold indicators. A floristic survey was then carried out with them. The plants and soils were collected from three sites and brought to the Biology Education Laboratory, University of Palangka Raya, Central Kalimantan, Indonesia, for plant identification and Au content analysis.

Plant species were identified based on their local name and habitus. In addition, plant identification was also completed by comparing their characteristics with pictures and descriptions of identified plants, including stems, leaves, flowers, and fruits, adjusted to the literature referring to (i) Tree Flora of Malaya Vol. 1, 2 and 3; (ii) Atlas of Indonesian Timber Vol. 1; (iii) Plant Resources of South–East–Asia No. 5; (iv) Borneo Island Medium and Heavy Hardwoods; and (v) reports and records relating to plant species.

Au analysis

The Au content was analyzed at the Laboratory of Environmental, Department of Chemistry, Faculty of Mathematics and Natural Sciences, Universitas Brawijaya, District, Indonesia. The Au content in plants and soil was determined through a quantitative approach using an atomic absorption spectrophotometer Type AA6200 at a wavelength of 242.8 nm, following the analytical procedure adapted from Vogel (2000). The data were then statistically analyzed using SPSS 25 with the Parametric Pearson Correlation test to determine the correlation and significance level of the Au content found in the plant and soil.

RESULTS AND DISCUSSION

Ethnobotanical knowledge analysis

The interview results revealed that 11 informants used plants to locate gold mining areas, while 10 and 4 informants applied soil characteristics and the trial-and-error method, respectively. It denotes that 44% of informants utilized plants to locate gold mining areas (Figure 2).

Furthermore, Figure 3 shows that the information about the plants used for locating a gold mining area was obtained from their parents and ancestors (32%), own experiences (52%), and friends (16%). It indicates that experience is vital in increasing the informant's knowledge to select gold mining areas. Besides, the calculation result demonstrated that the IAR value was 0.540. It means that 54% of the informants agreed that plants were utilized as gold indicators in the mining activity.

Plant identification and Au analysis

The inventory and identification results show that the informants utilized two plant species to determine gold mining areas, namely *kasuhui* (*Dipterocarpus* sp.) and *hara* (*Ficus racemosa* L.), where the pictures are displayed in Figure 4.

Table 1 shows the gold (Au) content in the plant tissues of *hara* and *kasuhui*. These plants seem to have the potential to take Au from the soil and translocate it in root, stem, and leaf tissues, although it generally translocates and accumulates iron (Fe) and lead (Pb) (Rajoo et al. 2016; Kaur et al. 2018). This result suggests that the local knowledge of the Dayak Ngaju Tribe can be scientifically justifiable.

Next, the data from Table 1 were used to analyze the correlation and significance level of Au content in the soil and plant tissues (root, stem, and leaf). The results exhibited significant positive correlations between Au contents in the *kasuhui* stem and the *hara* root and stem with the soils (Table 2).

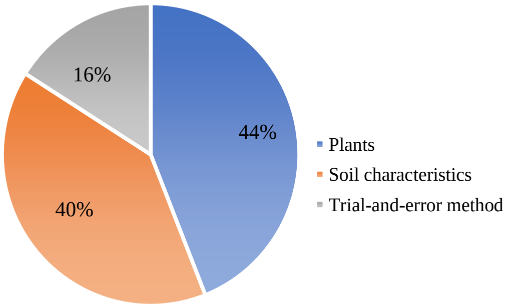

Figure 2. Percentage of the informants who apply specific techniques to locate gold mining area

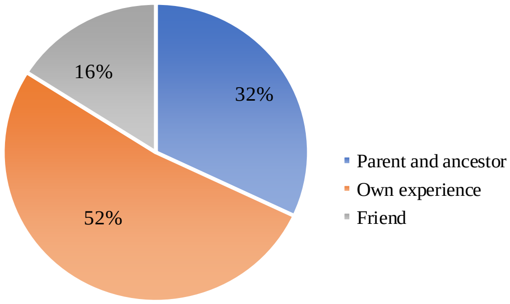

Figure 3. Percentage of the informants who received information from different sources to select gold mining area

Figure 4. Plant species used to locate gold mining areas: 1. *Kasuhui*, 2. *Hara* with A. leaves, B. fruits, and C. stems

Table 1. The Au content in the root, stem, leaf, and soil of two plant species used to locate gold mining area

Local name	Scientific name	Site	Au content (ppm)				$[Au]_{leaf}/[Au]_{root}$ quotient
			Root	Stem	Leaf	Soil	
Kasuhui	*Dipterocarpus* sp.	1	0.031	0.016	0.009	1.032	0.290
		2	0.058	0.039	0.026	1.268	0.448
		3	0.063	0.051	0.039	1.380	0.619
Hara	*Ficus racemosa* L.	1	0.021	0.012	0.013	1.916	0.619
		2	0.039	0.027	0.016	2.228	0.410
		3	0.056	0.038	0.027	2.516	0.482

Table 2. The correlation and significance level of Au content in the soil and plant tissues (root, stem, and leaf)

Plant name	Parameter	Root	Stem	Leaf
Kasuhui	*n*	3	3	3
	r	0.985	1.000*	0.992
	P	0.111	0.015	0.080
Hara	*n*	3	3	3
	r	1.000*	0.998*	0.942
	P	0.004	0.042	0.218

Note: *n*: The number of sites available; *r*: The Pearson's correlation coefficient; *P*: Significant Pearson's correlation; *: Correlation is significant at the 0.05 level

Discussion

Sei Riang is one of the villages in Gunung Mas District, Central Kalimantan, Indonesia, whose population is dominated by the Dayak Ngaju Tribe. For them, gold mining is carried out for a long time and passed down for generations. They believe gold mining can improve the local community's economy and increase Gunung Mas District's regional income. Based on anecdotal information from the local community, gold mining sites can be located using particular plants. It was proven by the interview results with local gold miners conducted in this study. The results demonstrated that 44% of the informants interviewed utilized plants, 40% assessed soil characteristics, and 16% employed the trial-and-error method to select gold mining locations (Figure 2). Thus, the selection method using plants can be considered more effective than assessing the soil characteristics or the trial-and-error method, which requires high costs and effort. In addition, one of the informants reported that the trial-and-error method could cause environmental damage during the process. Using the trial-and-error method, the local miners suck up the sediment of sand and mud in the riverbed for 1-2 hours. If sediment material containing gold ore or grains is found at the site, the mining activity will be continued. However, if no gold ore or grains are uncovered during the process, the mining activity must stop and move to a new location elsewhere. Accordingly, this activity is argued to cause environmental damage and pollution in the mining area. Therefore, this method is not recommended to use.

According to interview results, information on the use of plants as gold indicators was obtained by the miners mainly from their own experience (52%), then from their parents and ancestors (32%), and friends (16%) (Figure 3). This finding denotes that the knowledge of plants as gold indicators is more widely gained from self-experience than formal education in schools. It suggests that the schools have not yet played a role in developing scientific knowledge from empirical facts. Besides, this information was also relevant to the previous statement of Manningtyas and Furuya (2022), who pointed out that traditional ecological knowledge is an accumulation of ecological adaptation patterns of local communities that have been practiced and developed through the adaptation process.

According to plant inventory and identification results, *hara* (*F. racemosa*) and *kasuhui* (*Dipterocarpus* sp.) are plants that the informants usually used as gold indicators. Table 1 shows that these plants can potentially uptake gold (Au) from the soil and translocate it into their tissues. Although Kaur et al. (2018) mentioned that *hara* and *kasuhui* generally translocate and accumulate iron (Fe) and lead (Pb), they seem able to adapt to the presence of gold in the soil, even utilizing it in their physiological systems. It is also in line with research by Sunariyati (2018) that states the existence of gold in the plant is possible. In association with that, this research adds information on native plant species in Central Kalimantan to serve as a gold indicator.

Vural (2017) stated that several plants could accumulate gold in their roots, stems, and leaves. Gold contents are transported and translocated through the xylem as a chelate complex (Sunariyati et al. 2017b). On the other hand, this study's results revealed that the highest concentrations of gold were found in the root of *hara* and *kasuhui* plants, followed by their stems and leaves. It is probably because the roots act as a barrier for gold translocation and protect stem and other plant tissues from metal contamination. In addition, previous studies have also stated that three groups of higher plants could tolerate high heavy metal concentrations in the soil, i.e., excluder, indicator, and hyperaccumulator plants (Baker 1981; Kutty and Al-Mahaqeri 2016; Lam et al. 2022). The $[Au]_{leaf}/[Au]_{root}$ quotient values of *hara* and *kasuhui* were < 1, so they could be classified as excluders or indicator plants (Table 1).

The correlation and significance level of Au content in the plant tissues (root, stem, and leaf) and soils were analyzed to categorize plants as excluders or indicators. Significant positive correlations were discovered between Au contents in the *kasuhui* stem and the *hara* root and stem with their soils (Table 2). It reveals that the Au accumulation in the *kasuhui* and *hara* stems indicated the presence of Au in their soils. It also suggests the high contribution of plant stems in reflecting Au content in the soils, characterizing them as plant indicators for gold (Au).

Several plant species used as metal indicators are generally related to environmental characteristics. Knowledge of metal indicators can be applied to estimate the potential of land resources and characterize soil properties and polluted environments. To date, *Eucalyptus pellita* F.Muell., *Pterocarpus indicus* Willd., *Tectona grandis* L.f., and *Hibiscus tiliaceus* L. are plants recommended to be utilized as biogeochemical indicators in gold exploration in Indonesia (Sari 2018). This research might inform gold miners about the effectiveness of plants used as gold indicators in the soil for locating gold mining sites in the future. They are expected to be able to use the environment wisely while still considering conservation aspects. This pioneering research is deemed essential to lead to a 'green' alternative in selecting a potential gold mining area without causing damage to the environment.

In conclusion, the local community of Dayak Ngaju in Sei Riang Village, Central Kalimantan, has local knowledge of utilizing plants as gold indicators. *hara* (*F. racemosa*) and *kasuhui* (*Dipterocarpus* sp.) are plant species that could be used to detect the presence of gold in a mining area. This research is expected to promote the ethnobotanical knowledge of the Dayak Ngaju people to determine the gold mining locations, which can be scientifically justified. Nevertheless, this research still had limitations in obtaining information due to the small number of informants interviewed. We believe that many plant species in the Central Kalimantan have not been adequately explored and documented as gold indicators. Therefore, we suggest conducting further research by employing more informants and studies in other gold mining areas in Central Kalimantan. It is done to strengthen data in the plant exploration that have the potential as gold indicators.

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REFERENCES

Alexiades MN. 1996. Ethnobotanical Research: A Field Manual New York. Institute of Economic Botany, New York.

Baker AJM. 1981. Accumulators and excluders-strategies in the response of plants to heavy metals. J Plant Nutr 3: 643-654. DOI: 10.1080/01904168109362867.

Eldeen IMS, Effendy MAW, Tengku-Muhammad TS. 2016. Ethnobotany: Challenges and future perspectives. Res J Med Plant 10 (6-7): 382-387. DOI: 10.3923/rjmp.2016.382.387.

Jadid N, Kurnaiawan E, Himayani CES, Andriyani, Prasetyowati I, Purwani KI, Muslihatin W, Hidayati D, Tjahjaningrum ITD. 2020. An ethnobotanical study of medicinal plants used by the Tengger Tribe in Ngadisari Village, Indonesia. PLoS One 15 (7): e0235886. DOI: 10.1371/journal.pone.0235886.

Karyani L. 2021. Relay translation on Dayak Ngaju, Indonesian, and English: Analysis on cultural terms in *Dayak* mythology "Tatum". Proceedings of the First International Conference on Democracy and Social Transformation, ICON-DEMOST, Semarang, 15 September 2021. DOI: 10.4108/eai.15-9-2021.2315606.

Kaur I, Khandwekar S, Chauhan R, Singh V, Jadhav, SK, Tiwari, KL, Quraishi A. 2018. Exploring the efficiency of native tree species grown at mine tailings for phytoextraction of lead and iron. Proc Natl Acad Sci India Sect B Biol Sci 89: 951-956. DOI: 10.1007/s40011-018-1010-0.

Kutty AA, Al-Mahaqeri SA. 2016. An investigation of the levels and distribution of selected heavy metals in sediments and plant species within the vicinity of ex-iron mine in Bukit Besi. J Chem 2016 (2096147): 1-12. DOI: 10.1155/2016/2096147.

Lam EJ, Keith BF, Bech J, Alvarez, FA, Zetola V, Pereira LH, Montofré, IL. 2022. Characteristic curve modeling of plant species behavior in soils with heavy metals. Environ Geochem Health 2022: 1-14. DOI: 10.1007/s10653-022-01342-5.

Listiani, Abrori FM. 2018. Ethnobotanical study on Tidung Tribe in using plants for medicine, spice, and ceremony. IPTEK J Technol Sci 29 (1): 2088-2033. DOI: 10.12962/j20882033.v29i1.3057.

Manningtyas RDT, Furuya K. 2022. Traditional ecological knowledge versus ecological wisdom: are they dissimilar in cultural landscape research? Land 11 (8): 1123-1139. DOI: 10.3390/land11081123.

Navia ZI, Suwardi AB, Baihaqi. 2021. Ethnobotanical study of medicinal plants used by local communities in Sekerak Subdistrict, Aceh Tamiang, Indonesia. Biodiversitas 22 (10): 4273-4281. DOI: 10.13057/biodiv/d221019.

Pandey AK, Tripathi YC. 2017. Ethnobotany and its relevance in contemporary research. J Med Plants 5 (3): 123-129. DOI: 10.1016/j.jep.2020.112745.

Pei S, Alan H, Wang Y. 2020. Vital roles for ethnobotany in conservation and sustainable development. Plant Divers 42 (6): 399-400. DOI: 10.1016/j.pld.2020.12.001.

Pisco RR, Yarce JPG, Restrepo JJG, Palacio DG. 2017. Gold phytoextraction and mining-degraded soil reclamation. Acta Agron 66 (4): 574-579. DOI: 10.15446/acag.v66n4.59773.

Rajoo KS, Karam DS, Arifin A, Mu*Hara*m FM. 2016. Phytoremediation potential of *Dipterocarpus chataceus* planted on sewage sludge contaminated soil. Middle East J Sci Res 24 (4): 1169-1177. DOI: 10.1016/j.ufug.2021.127340.

Sari MU. 2018. Anaysis of gold particles in *Eucalyptus Pellita*, Angsana, Jati, and Waru leaves in Indonesia using Atomic Absorption Spectroscopy (AAS) and inductively coupled plasma-atomic emission spectroscopy (ICP-AES). [Thesis]. Universitas Gadjah Mada, Yogyakarta. [Indonesia]

Sheoran V, Sheoran AS, Poonia P. 2013. Phytomining of gold: A review. J Geochem Explor 128: 42-50. DOI: 10.1016/j.gexplo.2013.01.008.

Sunariyati S, Amin M, Hakim L. 2017b. Potensi akumulasi aurum (Au) pada beberapa jenis tumbuhan di wilayah penambangan emas Kapuas Tengah. JPLB 1 (3): 33-42. DOI: 10.36813/jplb.1.3.34-43. [Indonesian]

Sunariyati S, Suatma, Miranda Y. 2017a. Pengembangan praktikum biologi di sekolah menengah berbasis etnobiologi. EDUSAINS 9 (2): 212-22. DOI: 10.15408/es.v9i2.6580. [Indonesian]

Sunariyati S. 2018. Ethnobotanical studies of plants utilization in the gold mining region in Central Kapuas, Indonesia. Biodiversitas 19: 215-221. DOI: 10.13057/biodiv/d190129

Susandarini R, Khasanah U, Rosalia N. 2021. Ethnobotanical study of plants used as food and for maternal health care by the Malays communities in Kampar Kiri Hulu, Riau, Indonesia. Biodiversitas 22 (6): 3111-3120. DOI: 10.13057/biodiv/d220613.

Sutrisno IH, Akob B, Navia ZI, Nuraini, Suwardi AB. 2020. Documentation of ritual plants used among the Aceh Tribe in Peureulak, East Aceh District, Indonesia. Biodiversitas 21 (11): 4990-4998. DOI: 10.13057/biodiv/d211102.

Ullah F, Ayaz A, Saqib S, Zaman W, Butt MA, Ullah A. 2019. *Silene conoidea* L.: A review on its systematic, ethnobotany and phytochemical profile. Plant Sci Today 6 (4): 373-382. DOI: 10.14719/pst.2019.6.4.571.

Vogel AI. 2000. Textbook of Quantitative Chemical Analysis 6th ed. Prentice Hall, London.

Vural. 2017. Gold and silver content of plant *Helichrysum arenarium*, popularly known as the golden flower, growing in gümüşhane, ne Turkey. Acta Phys Pol A 132: 978-980. DOI: 10.12693/APhysPolA.132.978.