International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Healthy Index Level of Mangrove Forests around Sylvo-Ecotourism in Tanjungpiayu and Kabil, Batam Island

Diana Azizah[1], Febrianti Lestari[2], Deni Sabriyati[3], Bontor L. Tobing[4], Muhammad Hendy Noordianto[5], Bagus Dwi Rahmanto[6], Yales Veva Jaya[7]

[1,2,3]Faculty of Marine Science and Fisheries, Universitas Maritim Raja Ali Haji, Riau Islands, Indonesia.
[4,5,6]Official Member of BPDASHL Sei Jang Duriangkang – Riau Islands, Indonesia
[7]Head of Center for Maritime Empowerment, Batam City, Riau Islands, Indonesia

Abstract
The existence of mangrove forests in several coastal areas of Batam Island is threatened by the development of settlements and ports as well as industrial activities. Environmental changes due to land clearing have an impact on the health of the surrounding mangrove forests. In fact, several mangrove forest areas in Batam City have the potential to be developed as mangrove sylvo-ecotourism areas. The decline in the health of mangrove forests around land conversion areas can be seen from the level of tree damage. Mangrove tree sampling was carried out in Tanjungpiayu Village and Kabil Village in Batam, Riau Islands Province. Sampling of tree stands using cluster plots. The tree health index is observed based on the percentage of damage locations, type and severity of tree damage. The research results showed that the mangroves around the sampling location were considered healthy even though there was light and moderate damage. The worst damage locations are on the leaves, roots and lower stem. The most types of damage were in other categories (submerged in red mud), damaged and discoloured leaves, termites, broken or dead roots and stems. The most severe levels occur around 10-20%, 30% and 90%. The health of the mangroves in the Tanjungpiayu and Kabil mangrove sylvo-ecotourism areas is still relatively good.

Keywords: Mangrove Healty, Batam Island, Sylvo-Ecotourism.

1. Introduction

Batam Island in Indonesia's Riau Archipelago has the potential to become a strategic area to support the economy through the development of industrial and shipping areas. So that reclamation activities and land clearing for conversion continue to be carried out with the area increasing from year to year. Areas that have been converted have resulted in changes in the conditions of the surrounding water environment. This will threaten the existence of the surrounding coastal ecosystem. The most prominent characteristic of environmental changes around areas that have been converted is the condition of the land which is heavily damaged, causing heavy erosion, thin topsoil and even loss of humus. The influence of reclamation and land clearing on the physical properties of land in the city of Batam does not only occur in mainland forests but also occurs in mangrove forest areas. Mangroves are plants that really depend on a type of soil

structure that is muddy and rich in organic material to support life. Because mangroves depend on their root systems to adapt. So if there is a change in the surrounding environmental parameters, it will directly affect the adaptation mechanism.

Several mangrove forest areas in Batam City are managed by BPDASHL Sei Jang Duriangkang Riau Islands. Such as the mangrove forests found in Tanjungpiayu Village in Sei Beduk District and Kabil Village in Nongsa District. The position of the mangrove forest which is located not far from the city centre makes the mangrove function as the lungs of Batam City. Currently, the mangrove forests around Sei Beduk and Nongsa Districts are not only used for settlement and reclamation, but are also used as ponds (sylvo-fishery) which are then being developed into mangrove forest ecotourism areas (sylvo-ecotourism).

Mangrove adaptation to the environment can be measured by the health condition of the trees. Healthy trees will reflect good adaptation to changes in the surrounding environment. Mangrove forest health is an effort to control the level of forest destruction so that it can guarantee the function and benefits of the forest. The quality of mangrove forests in Batam will influence the function of mangrove forests in its coastal areas. Even though the surrounding area has been converted into residential, industrial and port areas, the health of the remaining living mangrove trees in the surrounding area needs to be protected so that their ecological (production, protection and conservation), economic and social functions remain sustainable. Assessment of the health of the trees that make up the mangrove forest stands in Batam can be done by looking at the damage that occurs to the mangrove trees. The information obtained can be used as a basis for developing strategies to control mangrove damage and mangrove ecosystem management policies for better sylvo-ecotourism on Batam Island.

2. Materials and Method

This research was carried out from September to December 2023 on the coast of Batam Island which is a sylvo-ecoturism area in Tanjungpiayu and Kabil. The tools used in the sampling consisted of tally sheet, roller meter, tape, Global Positioning System (GPS), digital camera, markers, label paper, and plastic. The object of this research is all types of mangroves contained in the cluster plot.

Collecting research data is by observing the damaged condition of mangrove trees which refers to the Forest Health Monitoring (FHM) method [3][4]. The cluster plot design is a double circular plot with 4 (four) sites at each sampling location (Figure 1). Parameters of tree damage observed consisted of location of damage, type of damage and severity. The location of the damage is found in the roots, stems, branches, canopy, leaves, shoots and shoots of trees. The type of damage consisted of 3 (three) types of damage which were mostly found in tree stands, then the damage was assessed based on the severity threshold from 10% to 90%. Each category is assigned a code and a weight symbolized by X (location of damage), Y (type of damage) and Z (percentage of severity). The code of observation used in the analysis of damage to mangrove trees refers to [5] and [4] (Table 1). Mangrove damage index uses calculations according to [6]. To calculate the condition of tree damage by multiplying the weights (x, y, and z) to determine the damage index. The results of the final calculation can be seen the health category of mangrove trees. The formula used is:

$$\textit{Damage Index Value at Tree Level (NIK)} = \sum_{i=1}^{n}(xi, yi, zi)$$

Tree damage class refers to the weighted index value with the following criteria: Healthy class = 0 to < 5; Light damage class = 6 to 10; Medium damage class = 11 to 15; Heavy damage class = 16 to > 21.

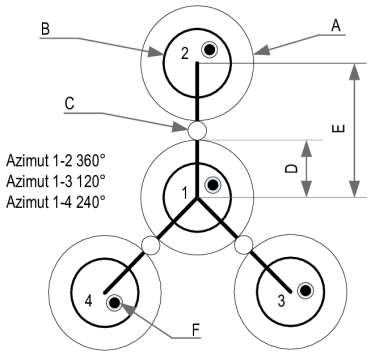

Figure 1. FHM cluster-plot design [5]. Note: A = Annular plot radius 17.95 m; B = 7.32 m radius subplot; C= soil sample point; D = the distance of the soil sample point from the centre of the subplot is 18 m; E = distance between plot centres is 36.6 m; F = micro plot radius 2.07 m per azimuth and distance from centre point of subplot is 3.66 m.

Table 1. Code, location, type, severity and weight calculation of mangrove tree damage

Code	Location of damage	value (x)	Code	Type of damage	value (y)	Code	Level of damage (%)	value (z)
0	Healthy (no damage)	0.0	1	Cancer	1.9	0	0	1.5
1	Roots	2.0	2	*Konk*	1.7	1	10	1.1
2	roots & bottom of stems	2.0	3	Open wound	1.5	2	20	1.2
3	Bottom of stems	1.8	4	*Resinosis*	1.5	3	30	1.3
4	Bottom of stems & upper	1.8	5	Broken stem	2.0	4	40	1.4
5	Upper stems	1.6	6	Termite nest	1.5	5	50	1.5
6	Stem section header	1.2	11	Broken stems/roots	2.0	6	60	1.6
7	Branch	1.0	12	*Brum* on root/stem	1.6	7	70	1.7
8	Buds	1.0	13	Broken/dead roots	1.5	8	80	1.8
9	Leafs	1.0	20	*Liana*	1.5	9	90	1.9

Code	Location of damage	value (x)	Code	Type of damage	value (y)	Code	Level of damage (%)	value (z)
			21	Dead of buds	1.3			
			22	Broken/dead branch	1.3			
			23	*Brum*	1.3			
			24	Damaged leaves, buds	1.3			
			25	Leaves changing colour	1.0			
			26	Puru rust	1.9			
			31	Others	1.0			

3. Results

The mangrove vegetation found in Tanjungpiayu and Kabil of Batam Island consists of 10 types of mangroves including: two species from the genus Avicennia (*A. alba* and *A. marina*); two species of the genus Rhizopora (*R. apiculata* and *R. mucronata*); two species from the genus Bruguiera (*B. gymnorhiza* and *B. cylindrical*); two species of the genus Xylocarpus (*X. granatum* and *X. mollucensis*); the species *Ceriops tagal*, and *Sonneratia alba*. The kind of mangrove species are presented in Table 2.

Table 2. Composition of Mangrove Types Found Around the Bintan Island Post-Bauxite Mining Area

No.	Species	Local name	Family	Existence discovered	
				Tanjungpiayu	Kabil
1.	*Avicennia alba*	Api-api	Avicenniaceae	√	√
2.	*Avicennia marina*	Api-api	Avicenniaceae	√	√
3.	*Rhizopora apiculata*	Bakau	Rhizophoraceae	√	√
4.	*Rhizopora mucronata*	Bakau hitam	Rhizophoraceae	√	√
5.	*Ceriops tagal*	Tenggirih	Rhizophoraceae		√
6.	*Bruguiera gymnorhiza*	Tanjang	Rhizophoraceae		√
7.	*Bruguiera cylindrica*	Tumu	Rhizophoraceae		√
8.	*Sonneratia alba*	Pedada/Perepat	Sonneratiaceae		√
9.	*Xylocarpus granatum*	Penyirih	Meliaceae	√	√
10.	*Xylocarpus mollucensis*	Penyirih	Meliaceae		√

The location of damage to mangrove organs around the former bauxite mining area are presented in Table 3, was found in 127 cases where the most types of cases were in the leaves (30 cases; 23.6%), roots (24 cases; 18.9%) and lower stems (19 cases; 15%). Meanwhile, damage to other organs only ranged from 1-4.7% (Table 3). No damage was found to the upper stem organs and crown. The types of mangroves that experienced the most damage in Kabil Village were *Rizhophora Apiculata*, *R. mucronata* and *A. marina*, while in Tanjungpiayu Village, apart from these 3 types, *Xilocarpus Granatum* was also found.

Table 3. Percentage of Number of Mangrove Trees Based on Location of Tree Damage (Organs).

Code	Damage Location	Tanjung-piayu (Case)	Kabil (Case)	Number (trees)	Percentage (%)
0	Healthy	25	12	37	29.1
1	Roots	12	12	24	18.9
2	Roots and bottom of stem	12	7	19	15.0
3	Bottom of stem	3	3	6	4.7
4	Bottom and upper stem	4	2	6	4.7
5	Upper stem	0	0	0	0.0
6	Stem section header	1	1	2	1.6
7	Branch	1	2	3	2.4
8	Buds	0	0	0	0.0
9	Leaves	16	14	30	23.6
Total				**127**	**100**

Based on the results of observations of the type of damage, damage was found such as resinosis, broken stem, termite nest, broken stems/roots, broken/dead roots, broken/dead branches, damaged leaves/buds, leaves changing colour and others. The type of damage that is most frequently found is roots covered in red mud sediment which is thought to have come from opened area by erosion (as the "other" type of damage at 28.9%), followed by damaged leaves/buds (17.8 %), leaves changing colour (15.6%), termite nest (14.4%) and broken/dead roots (10%), while other types of damage found were classified as < 10%, namely resinosis 1.1%, broken stem 2.2%, broken stems/roots 7.8 % and broken/dead branches 2.2 % (Table 4.)

Table 4. Types of Damage Based on Types of Diseases Found in Mangrove Trees

Code	Damage type	Tanjung-piayu (cases)	Kabil (cases)	Num-ber (Cases)	Percent-age (%)
1	Cancer	0	0	0	0.0
2	Konk	0	0	0	0.0
3	Open wound	0	0	0	0.0
4	Resinosis	0	1	1	1.1
5	Broken stem	1	1	2	2.2

6	Termite nest	7	6	13	14.4
11	Broken stems/roots	5	2	7	7.8
12	Brum on roots/stems	0	0	0	0.0
13	Broken/dead roots	5	4	9	10.0
20	Liana	0	0	0	0.0
21	Dead of buds	0	0	0	0.0
22	Broken/dead branch	1	1	2	2.2
23	Brum	0	0	0	0.0
24	Damage leaves/buds	9	7	16	17.8
25	Leaves changing col-our	8	6	14	15.6
26	Puru nust	0	0	0	0.0
31	Other	13	13	26	28.9
Total				**90**	**100**

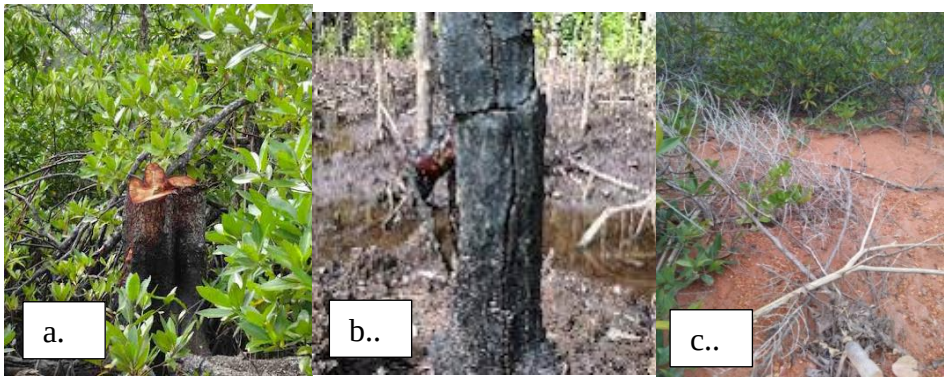

Figure 2. Condition of damaged tree branches/trunks: (a) open wounds, (b) and (c) broken/dead branches or trunks

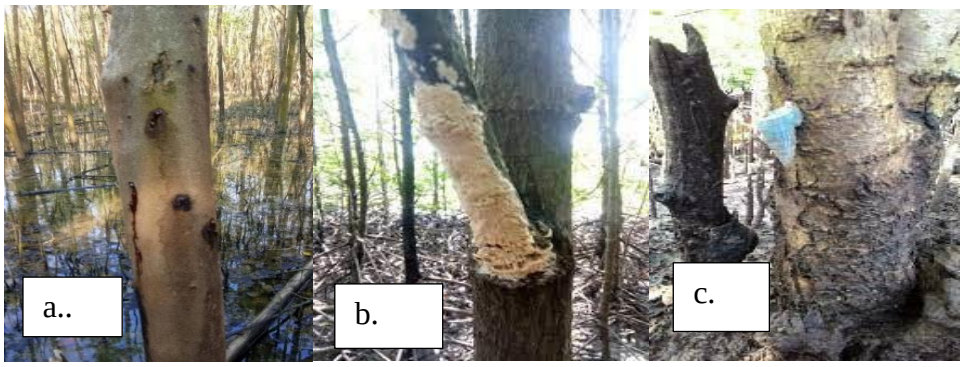

Figure 3. Types of tree trunk diseases (a) gummosis, (b) and (c) Termite nests

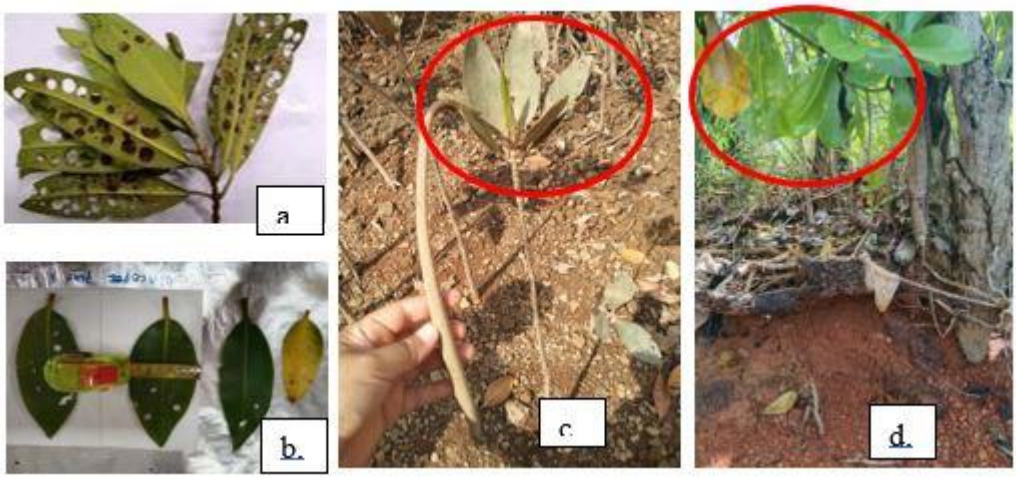

Figure 4. Damaged leaves: (a) leaves with holes, (b) discoloured leaf samples, (c) and (d) discoloured leaves

The resinosis/gummosis condition was found on the branches of *R. apiculata* and the lower stem of *B. gymnorhiza*. Gummosis is a thick, dark brown fluid that comes out of injured or perforated tree organs (Figure 3a). The termite nests observed were found on *R. apiculata* tree trunks. Termites cause tree trunks to peel and have small holes in large numbers (Figures 3b and 3c). According to [7], the presence of termites on stems is characterized by the discovery of a crust of soil covering parts of the stem and can result in the death of the plant. Termite attacks do not only occur on one tree but can spread to other trees through trunks, branches, twigs on the forest floor or from lianas on the tree. Types of damage to broken stems, broken, broken/dead roots and broken/dead branches were found in *A. alba*, *A. marina*, *R. apiculata*, *R. mucronata*, *S. alba*, *C. tagal* and *X. granatum* trees. The damage it causes is the loss of the tips or bases of the twigs and leaves, as occurs when the dead branches are weathered (Figure 2b and c). The cause is thought to be due to the activities of local residents entering the mangrove forest area, winds that are too strong or weathering. Apart from that, there were as many damaged leaves and as many discoloured leaves. Symptoms that can be seen include leaf chlorosis (lack of green substance) such as turning yellow or brownish, having brown or black spots and wilting leaves (Figure 4). Stated that symptoms of damage to leaves can be caused by chlorophyll not being formed due to the presence of pathogens, toxins, excess chemicals or being burned by temperatures that are too high.

The severity level is the percentage of the type of damage found on a tree. Severity level of damage to mangrove trees around the sylvo-ecotourism mangrove in Tanjungpiayu and Kabil presented in Table 5. A severity level of 90% was found in 12 cases (9.4%), while the lowest severity level, namely 10%, was found in 19 cases (15%) and 20% was found in 31 cases (24.4%). Percentage of number of mangrove trees based on level of damage are presented in Table 6.

Table 5. Severity Level of Damage to Mangrove Trees Around The Former Bauxite Mining Area

Code	Severity level (%)	Tanjungpiayu (Cases)	Kabil\ (Cases)	Number	%
0	0	25	12	37	29.1
1	10	14	5	19	15.0
2	20	15	16	31	24.4

3	30	6	4	10	7.9
4	40	0	0	0	0.0
5	50	7	8	15	11.8
6	60	0	0	0	0.0
7	70	0	3	3	2.4
8	80	0	0	0	0.0
9	90	7	5	12	9.4
Total				**127**	**100**

Table 6. Percentage of Number of Mangrove Trees Based on Level of Damage

Sampling Area	**Number of Tress based on damage cases (Trees)**			**Number of Healthy trees (Trees)**
	Lightly	Medium	Heavy	
Tanjungpiayu	15	2	0	28
Kabil	9	3	0	17
Percentage (%)	32,4	6,8	0	60,8

The research results showed that from a total of 75 samples of mangrove trees in Tanjungpiayu and Kabil Village, there were 29 mangrove tree samples that were damaged. In general, the mangrove forests in Batam Regency around the sylvo-ecotourism site are still relatively healthy and have light to moderate damage. Based on the details of the damage, the level of damage to trees classified as light was 32.4% (24 mangrove tree samples) and moderately damaged was 6.8% (5 mangrove tree samples), while the healthy mangrove tree category was found to be 60.8% (45 mangrove tree samples). Thus, most of the mangrove forests around the sylvo-ecotourism area in Batam are predominantly healthy.

The health condition of mangrove forests in Tanjungpinang City is in a similar condition, namely healthy (50.9%), slightly damaged (40.4%) and moderately damaged (8.8%). Likewise, the locations of the organs that are most damaged are the roots, lower and upper stems, and leaves. The most common type of damage found in roots submerged in red mud; stems and leaves covered with red dust and sand; termite; broken stem; roots break and die; broken shoots; and the leaves change color. The greatest level of severity is found to be between 10% and 20%.

The results of research stated that the sediment conditions on Riau Islands which contain bauxite minerals have potential. However, due to the absence of efforts to restore the ex-mining land, it resulted in physical damage in the form of erosion and red mud sedimentation along the beaches and mangrove forests. Apart from that, according to [9], based on the level of environmental pollution, mangrove forests in Riau Island have experienced Pb and Cr metal contamination, although this has not yet increased to become a pollution case, while the environmental condition of mangrove forests based on the Geological Index has experienced environmental pollution. It is clear that this condition cannot be allowed to continue. Efforts need to be made to restore land or restore sediment conditions around mangrove forest areas in Batam Island.

4. Conclusion

The 10 types of mangrove vegetation around the sylvo-ecotourism area in Tanjungpiayu and Kabil, it was found that almost 40% of the mangrove forests were classified as experiencing light damage, and only

around <10% experienced moderate damage. The location of damage (organs) to mangrove trees is dominated by the leaves, roots and lower trunk of the tree. The types of damage found consisted of root coverage by red mud for all kind of mangroves, damaged leaves/buds, leaves changing color and termite nests (*Rhizopora* sp), as well as broken roots (*Rhizhopora* sp, *Sonneratia* sp, *Ceriops* sp, and *Xylocarpus* sp). Based on the percentage of severity of damage, it was found that the greatest severity of damage was around 20% of all cases found.

5. Acknowledgement

Diana Azizah, Febrianti Lestari, and Deni Sabriyati are active lecturer on Faculty of Marine Science and Fisheries, Universitas Maritim Raja Ali Haji, Riau Islands, Indonesia. Prepared this journal article based on the report of Healthy Index Level of Mangrove Forests around Sylvo-Ecotourism in Tanjungpiayu and Kabil, Batam Island. This work has been funded by Universitas Maritim Raja Ali Haji under the programme of Matching Fund Universitas Mariritim Raja Ali Haji year of 2023. The funding is also a real commitment of Universitas Maritim Raja Ali Haji to support the the Matching Fund Implementation Program through the Kedaireka platform by the Ditjen DIKTI Kemendikbud Ristek Dikti year of 2023. The opinions expresses here in are those of the authors and do not necessarily reflect the views of funding agency."

6. References

1. ITTO. Criteria and Indicators for Sustainable Management of Natural Tropical Forests. ITTO Policy Development Series Nomor 7. Yokohama: ITTO. (1998).
2. Safe'i, R, Wulandari, C., &; Kaskoyo, H. *Forest health assessment on various types of forests in Lampung Province*. Sylva Lestari Journal, 7(1), 95–109. http://repository.lppm.unila.ac.id/id/eprint/26323 (2019).
3. Safe'i, R., Hardjanto., Supriyanto., Sundawati, L. Development of sengon community forest health assessment method ((Miq.) Barneby & J.W. Grimes). Journal of Plantation Research, 12(3). Pp. 175-187. (2015).
4. Safe'i, R., Kasykoyo, H., and Darmawan, A. Tree Health Analysis Using Forest Health Monitoring Method (Case Study on Three Forest Functions in Lampung Province). SemNASN MAPIAUB (2020).
5. Mangold, R. *Forest Health Monitoring: Field Methods Guide* (International-Indonesia). Washington DC: USDA Forest Service. 300 p (1997).
6. Nuhamara, S.T., Kasno., dan Irawan U.S. *Assessment on Damage Indicators in Forest Health Monitoring to Monitor the Sustainability of Indonesian Tropical Rain Forest*. In: Forest Health Monitoring to Monitor The Sustainability of Indonesian Tropical Rain Forest. Volume II. Japan (JP): ITTO dan Bogor(ID): SEAMEO-BIOTROP. (2001).
7. Safe'i, R., Kaskoyo, H., Darmawan, A., and Rezinda, C.F.G. *Analysis of Changes in Forest Health Status Values in Conservation Forest (Case Study: Plant and Animal Collection Blocks in Wan Abdul Rachman Forest Park (Tahura WAR)*. Journal of Physics: Conference Series. 1-12. (2020).
8. Apriliyani, Y., Safe'i, R., Kaskoyo, H. Wulandari, C., and Febryano, G.I. Analysis of mangrove forest health assessment in East Lampung District. Journal of Tropical Forests. 8(2): 123-130. (2020).
9. Azizah, D., Hamidy, R., Mubarak, Efriyeldi, Muzammil, W., Lestari F., and Murtini S. *Index of Mangrove Health Around the Ex-Bauxite Mining Area, Tanjungpinang City, Riau Islands Province*. E3S

Web Conf. Volume 324, MaCiFIC 2021. https://doi.org/10.1051/e3sconf/202132401008 (2021).

10. Azizah, D., Lestari, F., Susiana, Kurniawan, D., Melany, W. R., Apriadi, T., and Murtini, S. *IOP Conf. Ser.: Earth Environ. Sci.* 967 012016. **DOI** 10.1088/1755-1315/967/1/012016 https://iop-science.iop.org/article/10.1088/1755-1315/967/1/012016/meta (2022)