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MOSS AS BIOINDICATORS FOR POLLUTION AT FRASER HILL AND CAMERON HIGHLAND PAHANG MALAYSIA

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Abstract

Tropical Montane Cloud Forest (TMCF) is one of Earth's most neglected ecosystems around the globe. More than half of these forests are situated within Southeast Asia. Malaysia is known for its numerous mountains that are exceptionally rich in biodiversity and locally endemic species, but they are also threatened by expanding human activity such as forestry, agriculture, infrastructure, and climate change. The study aims to critically assess the current state of moist TMCF, focusing on their physical and biological potentials as Bio indicators through Bio monitoring at Fraser Hill and Cameron Highland, Pahang, Malaysia. The mix-methods of observation surveys are to identify physical attributes such as light intensity, altitudes, temperature, wind velocity and air humidity. Secondly, laboratory tests are to identify heavy metal contamination absorbed by mosses. Based on the findings collected around the trails, a connection between altitude and microclimate could be found. The study finds that as the altitude increases and the temperature decreases, the vegetation becomes more dwarfed. Secondly, results from the analysis at Abu Suradi trail within Fraser Hill and Brinchang Trail within Cameron Highland have a higher average of aluminium and iron concentration. Mosses were manifested as good key indicators of air pollution with heavy metals to Malaysia highland forest ecosystems. It showed differential accumulation of heavy metals located near sources of pollution. Thus, the moss data confirms the persistence of risk of pollution of highland forest ecosystems in Malaysia, which demands environmental management. Furthermore, decision makers, planners and designers around the region can evaluate and improve their local strategies related to Tropical Montane Cloud Forest (TMCF) conservation and preservation, especially highlands such as Fraser Hill and Cameron Highland.

***Keywords**:* Tropical Montane Cloud Forest (TMCF), Ecosystem, Bio Indicator, Bio monitoring.

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INTRODUCTION

Tropical Mount Cloud Forest (TMCF) has been reaching attention among people and researchers due to unique characteristics of flora and fauna. There are many definitions that have been debated and the main character of the forest usually has direct canopy interception of cloud water at high altitude (Boehmer, 2011 & Ramirez et al., 2017). Malaysia's cloud forest, can be said to be some of the best-documented in the region, in which some research describing local distribution, physiology, protection status, biological and ecological importance and threats to them exist (Peh et al., 2011 & Kumaran et al., 2011). Malaysia consists of two distinct parts: Peninsular Malaysia, which includes 11 states, with Titiwangsa Range forming the backbone of the Peninsular and East Malaysia. Covering two states, Sarawak and Sabah, which are located in the north and northwest of Borneo, the mountain rises sharply on a large inland mountain to the border of Kalimantan, Indonesia. Many mountains and its connection exist in Malaysia, about 7 percent of total land area which exceeds 900 meters height. On Malaysian mountains, cloud forests usually are made of shorter trees with higher stem density that are of twisted branches and twigs, solid crowns, sclerophyllous leaves that are smaller in size (Bruijnzeel, 2010; Boehmer, 2011; Peh et al., 2011; & Kumaran et al, 2011). With more elevation on the wet tropical mountains, different changes in appearance and forest structure are valid and noticed. Initially, this phenomenon changes gradually (Peh et al, 2011).

Malaysia's tropical montane cloud forest area originally sprawled around some 2.7 million hectares, but in the last decade within 23 percent have been destroyed or degraded (Sodhi & Brook, 2006). Around 9 percent or 216,300 hectares of cloud forest is protected either as a national park or as a wildlife reserve (Iremonger et al, 1997). Examples of these are Mount Tahan in West Malaysia, Mount Kinabalu National Parks in Sabah, and Mount Mulu National Park in Sarawak. Additional tropical montane cloud forests in Malaysia are within extractive reserves or various uses (IUCN-UNEP, 2010) or stated as mountain reserves. If these areas are included, Malaysia would have around 356,300 hectares or 15 percent cloud forest with some existing or planned protection levels (Iremonger et al, 1997). These estimations are still acceptable despite data being studied decades ago since the development of a small protected area in Malaysia in the early 1990s which has already existed (IUCN-UNEP, 2010).

Many types of management act have been introduced for further protection of the forest yet specific Tropical Montane Cloud Forest Management Act or protection method specifically for the ecosystem. Nevertheless, the tropical cloud forests in Malaysia are getting endangered and dismissed due to human activities, mainly infrastructure development. Preservation and conserving the ecosystem services provided by Tropical Montane Cloud Forest are essential for biodiversity and human benefits. In environmental pollution assessments, two important instruments are applied; bio-indicators and bio-monitors. These methods, cheap and simple, are used as visual environmental monitoring devices assessing species diversity and signs of external changes caused by human activities. Bio-indicators use organisms to analyse the quality of environment and any changes occur to the environment overtime through qualitative assessment. Often used as the primary focus of bio-indicator research, pollution and other natural stressors (droughts) for instance are attributed to nature disturbance.

Another approach is called quantitative assessment. Bio-monitors quantitatively determine a response from lichen (a symbiosis among algae, fungi and cynobacteria) and moss changes to indicate the level of severity in air pollution. Bio-monitors also serve as a tool to assess the level of depositions of pollutant components accumulated in organisms in the designated parameters. It traces the elements and directions of their distribution or any changes taking place in the ecosystem in historical paradigms, hence, a good marker of these processes (Lequy et al., 2019). In short, bio-indicators qualitatively assess biotic responses to environmental stress while bio-monitors quantitatively determine a response.
Mosses and lichens, on the other hand, are the best body to be bio-indicators to air pollutants. The unique characteristics, made them a significant agent, rely on atmosphere deposition for nourishment. They accumulate persistent atmospheric pollutants to concentrations far within the forest ecosystems (ie: in air quality, forest structure and climate). Without the presence of lichen, the forest ecosystem is at stake due to uncontrolled levels of sulfur dioxide, sulfur pollutants and nitrogen pollution (Holt et al., 2010). Thus, the study aims to evaluate the potential of moss species as bio-indicator for the highland environment at Fraser Hill and Cameron Highland in Pahang, Malaysia. The study focuses on two aspects, firstly, on the physical factor such as relation to the microclimate and secondly, relation to heavy metal concentration.

ABU SURADI TRAIL, FRASER'S HILL AND BRINCHANG TRAIL, CAMERON HIGHLAND

Fraser's Hill is formed by seven rolling hills with heights between 852 meters above sea level to 1,456 meters. Fraser's Hill is situated as least disturbed and the lowest between the three main hill stations in Titiwangsa Range or Main Range. Its location is located 100 kilometres from Kuala Lumpur, in the area of Raub, Pahang, covering an area of approximately 2,829 hectares. It is known that Fraser's Hill which is an environmentally sensitive area with fragile ecosystems and important areas especially for birds and highland biodiversity. Raub Local Plan 2003-2015 recommends wildlife sanctuaries to be formed. It is also listed as one of the main sites for ecotourism by the National Ecotourism Program.

The research location located in Fraser's Hills is on the Abu Suradi trail. Abu Suradi trail is located further up with an elevation of 1200 meters up to 1300 meters above sea level, temperature from 22-28 Celsius and 16-20 Celsius at night with humidity of 90%- and 2000-2500-mm rain within a year. The area surrounding the trail is robust with human activities consisting of tourism, agriculture and commercial buildings (Er et al, 2013). Meanwhile, Cameron Highlands is one of the most extensive hill stations in Malaysia, covering an area of 712 square kilometres where the boundaries touch Kelantan in the north and west, sharing some of its borders with Perak. It is located at the northwest tip of Pahang, about 90 kilometres from Ipoh and about 200 kilometres from Kuala Lumpur and is known as the smallest constituency in Pahang. Brinchang trail is located further up with an elevation of 1200 meters up to 2000 meters above sea level with an average annual temperature of 18 ° C (64 ° F). Temperatures rarely rise more than 25 ° C (77 ° F) during the day at night, they rarely fall to 9 ° C (48 ° F), only at higher altitudes.

MATERIAL AND METHOD

There are two variables that have been investigated, firstly the survey on the physical attributes of the site such as light intensity, altitudes, temperature, wind velocity and air humidity. Secondly, the samples of mosses were collected from Fraser's Hill and Cameron Highland in Pahang which are well-known tourism sites. The samples were collected based on altitudinal zones. The samples were taken right before Monsoon season starts to avoid fluctuations or sudden spikes in readings of results. All procedures were based on standard methods for the examination of dried plant tissue while our analysis was done based on Inductively *coupled plasma* mass spectrometry (*ICP*-MS).

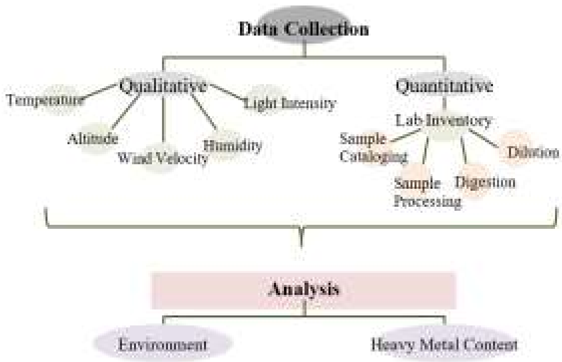

Figure 1: Summary of the research framework

MICROCLIMATE AND HEAVY METALS CONTAMINATION AT FRASER'S HILL

ABU SURADI TRAIL

Abu Suradi trail is located within Fraser's Hill, it is a public trail and is open to all members of the public and tourists. The trail's forest is surrounded by many human interventions such as agriculture, commercial activities and as a result it is very close to the road, though the location of the trail is near to human interactions, the altitude of the extraction points started higher at lowest 1238 metres above sea levels and highest being at 1279 metres above sea level. The temperature ranges between 19.3 to 20 degrees Celsius. Its wind velocity is between 0.2 up until 0.17 (m/s) with hu midity from 97.2 up to 99.2 (%rh) and Lux or light intensity measurement around 456 to 1973.

Table 1 shows the measurement recorded at extraction points of samples in Fraser's Hill on Abu Suradi trail, it shows that there are some relations between the reading of altitude and the reading of wind velocity and humidity by emphasising this with having almost similar pattern with one another. The table showed there was an increase in altitude reading when the wind velocity and humidity reading indicators were at the highest range. As the altitude level gets higher, the temperature of those environments were rather slimy and with wet conditions.

Table 1: Physical character of microclimate at Abu Suradi Trail, Fraser's Hill

Sample Id	Altitude	Temperature (oc)	Wind Velocity (m/s)	Humidity (%rh)	Lux
A.S.T 1A	1238	19.6	0.05	97.2	456
A.S.T 1B	1238	19.6	0.05	97.2	456
A.S.T 1C	1238	19.6	0.05	97.2	456
A.S.T 2A	1256	20	0.12	97.8	1973
A.S.T 2B	1256	20	0.12	97.8	1973
A.S.T 2C	1256	20	0.12	97.8	1973
A.S.T 3A	1260	19.9	0.4	97.4	526
A.S.T 3B	1260	19.9	0.4	97.4	526
A.S.T 3C	1260	19.9	0.4	97.4	526
A.S.T 4A	1264	19.5	0.2	98.2	258
A.S.T 4B	1264	19.5	0.2	98.2	258
A.S.T 4C	1264	19.5	0.2	98.2	258
A.S.T 5A	1270	19.6	0.18	99.2	544
A.S.T 5B	1270	19.6	0.18	99.2	544
A.S.T 5C	1270	19.6	0.18	99.2	544
A.S.T 6A	1279	19.3	0.17	97.9	1289
A.S.T 6B	1279	19.3	0.17	97.9	1289
A.S.T 6C	1279	19.3	0.17	97.9	1289
Mean	1261.167	19.65	0.186667	97.95	841

However, the lux reading did not show any significant score due to the nature of forest canopy which was open and shady. The results indicated that the indicative features of physical climatic conditions of the site survey at Abu Suradi trail suggested healthy, conducive and ideal growth of highland plant species such as mosses. Natural habitat for mosses often found at the forest floor and slopes and on woody and rocky surfaces ensured the healthy condition of the environment.

Furthermore, data collection of different species of mosses along Abu Suradi trail indicated there were traces of heavy metals concentrations found. These two typical moss families were known as 1) Calumperacea-*Calymperes afzelli* and 2) Sematophyllum-*Acanthorrhynchium papillatum.*

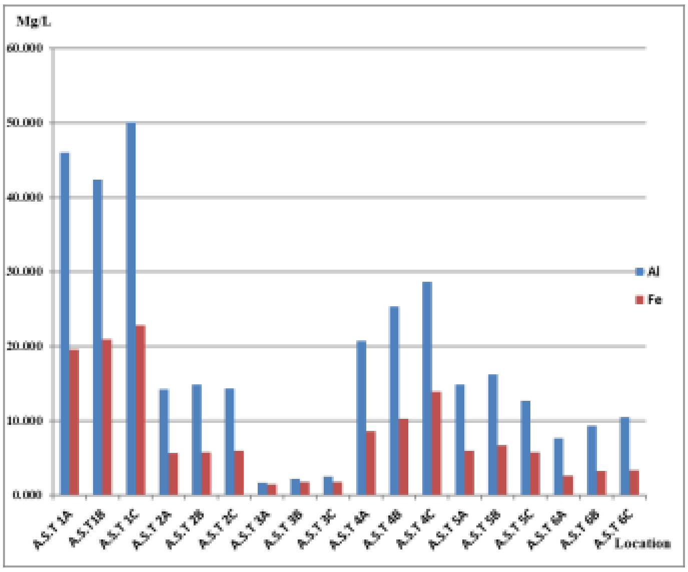

Figure 2: Heavy metal contamination at Abu Suradi trail, Fraser's Hill

Figure 2 indicates the amount of concentration in sample for Abu Suradi trail location, there were six sample locations chosen. From all the six spots, the first location which is A.S.T 1 has the most reading out of all for both Aluminium and Iron. Aluminium is > 40,000 Mg/L and Iron around 20.000 Mg/L. The second highest reading comes from location A.S.T 4. The ones that come afterward are from location A.S.T 2 and A.S.T 5 and the two last with the comparably lowest amount of concentration out of all locations are A.S.T 6 and A.S.T 3 < 10,000 Mg/L.

The increased contamination of A1 content with more than 1400mg/kg and Fe is more than 1900mg/kg shows a high level of air pollutant. Therefore, in

Figure 2, it proved that the sample soil taken from Abu Suradi trail contained increased capacity of accumulation of A1 and Fe content. Lack of concentrations of metals from Com Cu, Mn and Zn showed the site experienced an intense leaching process and faced potential risks of slope failure (Othman & Hasni, 2017).

MICROCLIMATE AND HEAVY METALS CONTAMINATION AT CAMERON HIGHLAND

BRINCHANG TRAIL

Brichang trail is located within Cameron Highlands located in it's Moss Forest Park, it is a public park but permission is needed from the Department of Forestry as part of the body of government that provides permits for any expedition as to control maximum capacity and for safety purposes. The trail is surrounded by thick muddy spongy forest away from the roads but is used by people as resting areas or a camping point. The altitude of the extraction points starts at 1963 metres above sea levels and goes up two metres, which is at 2000 metres above sea level. The temperature ranges between 15.8 to 16.8 degrees Celsius. Its wind velocity is between 0.17 and 0.78 (m/s) with humidity from 99.5 up to 100 (%rh) and lux or light intensity measurement around 665 to 1294.

The figure 3 below was designed based on measurements recorded at extraction points of samples in Cameron Highlands from Brinchang trail in Moss Forest Park. It shows that it is similar to findings on the Abu Suradi trail. There is a relation between the reading of altitude and the reading of wind velocity temperature, wind velocity and humidity by emphasising this with having almost similar pattern with one another. Figure 3, presented in the line graph shows an increase in temperature and wind velocity reading when there is an increase in altitude reading.

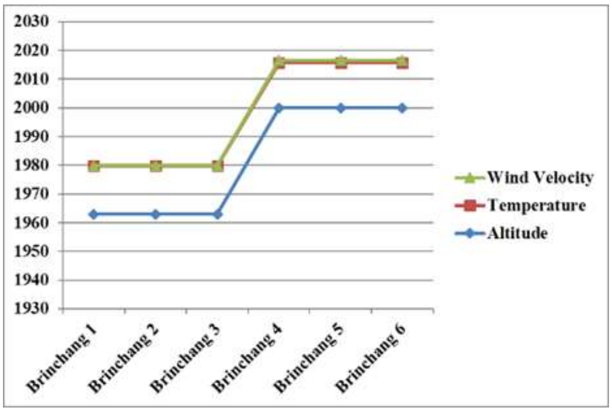

Figure 3: Physical character of microclimate graph of Brinchang Trail

Table 2: Physical Character of microclimate at Brinchang Trail, Cameron Highland

	Altitude	Temperature (oc)	Wind Velocity (m/s)	Humidity (%rh)	Lux
B 1A	1963	16.8	0.17	99.5	1294
B 1B	1963	16.8	0.17	99.5	1294
B 1C	1963	16.8	0.17	99.5	1294
B 2A	1963	16.8	0.17	99.5	1294
B 2B	1963	16.8	0.17	99.5	1294
B 2C	1963	16.8	0.17	99.5	1294
B 3A	1963	16.8	0.17	99.5	1294
B 3B	1963	16.8	0.17	99.5	1294
B 3C	1963	16.8	0.17	99.5	1294
B 4A	2000	15.8	0.78	100	665
B 4B	2000	15.8	0.78	100	665
B 4C	2000	15.8	0.78	100	665
B 5A	2000	15.8	0.78	100	665
B 5B	2000	15.8	0.78	100	665
B 5C	2000	15.8	0.78	100	665
B 5C	2000	15.8	0.78	100	665
B 6B	2000	15.8	0.78	100	665
B 6C	2000	15.8	0.78	100	665
Mean	1981.5	16.3	0.475	99.75	979.5

Other than that, several samples of moss species have been collected at Brinchang trail. There were two moss species found during data collection. The moss families in Brinchang is 1) Sematophyllaceae- *Acanthorrhynchium papillatum* and 2) Rhizogoniaceae- *Pyrrhobryum spiniforme*.

Figure 4, below stated the amount of concentration in the sample for Brinchang trail location, there were six sample locations chosen. From all the six spots, the first location which is B 1A has the most reading out of all for both Aluminium and Iron (> 10,000 Mg/L). The second highest reading comes from location B 2 (> 5.000 Mg/L). The ones that come afterwards are from location B 3. B 5 comes next and the two last with the comparably lowest concentration out of all locations are B 6 and B4 (< 5,000 Mg/L).

Similarly, to the Abu Suradi trail, the results showed high concentrations of A1 and Fe exceeded 1400mg/kg and 1900mg/kg significantly. This is due to the significant relationship of A1 and Fe concentrations with oxisol soil. The different degree of A1 substitution in iron oxides can reflect the environments in which they are formed (Othman et al., 2017).

As stated by Othman et al (2017), basic cations such as calcium, magnesium, and sodium leached away by rainwater from the soil because as compounds with chloride, they are very soluble whereas iron and aluminum that were released by weathering would remain at the site as they are highly insoluble compounds, so they cannot leach with percolating water. Conversely, under exceedingly acidic conditions some of the aluminum is solubilized as positively charged ions, mostly as $AlOH^{2+}$ and Al^{3+}. If they are percolated to surface waters in huge quantities, they can cause biological destruction and these soluble ions of aluminum are highly toxic to soil, animals and terrestrial plants. Iron oxides are important as cementation agents in soil as it acts to bind the soil particles in order to form aggregates and is difficult to be solved by water. Cementation occurs when iron oxide crystals occur in a space between particles. Then the crystals grow and interact with the soil particles and strengthen the bonds between the particles. Thus, the low percentage of iron oxide causes the soil to become friable and susceptible to collapse.

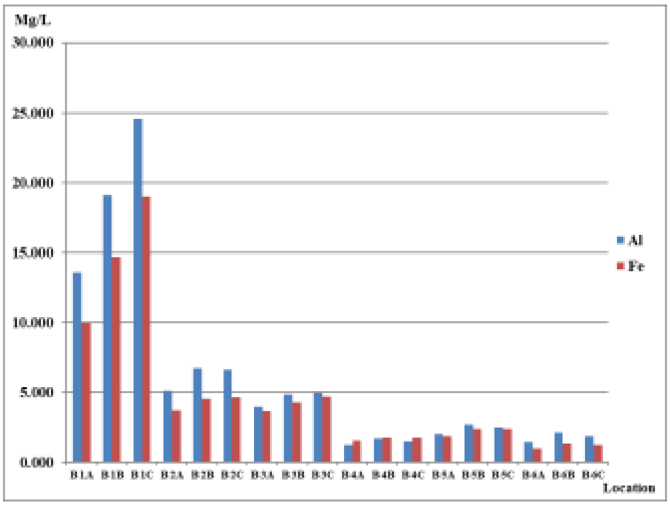

Figure 4: Aluminium and Iron graph of Brinchang Trail

CONCLUSION

Relation of moss species with local microclimate and heavy metal concentration

Tropical Montane Cloud Forest altitudes can be found within 2000 metres to 3500 metres but could as well go as low as 500 metres above sea level depending on the geographic condition and character (Boehmer, 2011 & Kumaran et al., 2011). Based on the findings collected around the trails, a connection between altitude and microclimate could be found. The study finds that as the altitude increases and the temperature decreases, the vegetation becomes more dwarfed or less compacted than lower tropical forest. This is most probably due to the microclimate of constantly being wet, not only that as the altitude increases so does the humidity as well as the wind velocity which could explain the reason for most vegetation within the area being dwarfed (Er et al., 2013 & Sodhi & Brook, 2006).

Meanwhile, certain tourism and land use activities play a role in increasing the environmental risk (Lequy et al 2019; Rabe et al., 2019 & Latip et al., 2020) such the level of heavy metal concentration within plant. In the light of heavy metals concentrations in mosses, the result confirmed that a higher value of aluminium heavy metal concentrations was found in Abu Suradi trail within Fraser's Hill and Brinchang Trail.

The land is located near the outer route, the main local source of pollution. Thus, this area is influenced significantly by the emissions of road transport and heavy traffic (Hoon Leh et al., 2020).

In conclusion, this research identifies some moss species and issues concerning Tropical Montane Cloud Forest which are rapidly and clearly diminishing from earth. Major conservation maintenance is required as it is impossible to cultivate once it is gone (Boehmer, 2011). The research concludes that mosses are good indicators of air pollution with heavy metals concentrations in the Malaysia forest ecosystem. With different levels of humidity and light, it confirmed the mosses to be persistent of risk of pollution of forest ecosystems. Mosses are indicative features contributing positively to the development of landscape ecology, often being a significant bio indicating tool to measure the environmental health of Malaysian forests. It effectively serves as a tracer of any climate changes or air pollutant due to heavy metals concentrations. At some point, the same indices can be of a useful tool to trace any macro and micro climate changes in the environment, both natural and man-made.

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