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# SOIL PHYSICOCHEMICAL PROPERTIES IN RESPONSE TO TREE PLANTING AT GUNUNG SIKU FOREST RESERVE, PAHANG

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**Abstract:** This study focused on soil chemical and physical properties of Compartment 5 of Gunung Siku Forest Reserve, Cameron Highlands five years after reforestation due to illegal opening for crop cultivation. Results showed that soil pH is moderately acidic to neutral, moderately coarse textured with strong brown colour, and with optimal percentage of soil organic matter. The soil at Gunung Siku Forest Reserve is fertile and suitable to aid the plant growth of the species planted which are characterized by sufficient level of macronutrients as well as low amounts of trace metals.

**Key words:** soil chemical properties, Cameron Highland, Gunung Siku Forest Reserve

## INTRODUCTION

Cameron Highlands, a small district located in State of Pahang which resides on Titiwangsa Range and bordering by two states; Kelantan and Perak (Barrow & Chan 2005). Cameron Highland was gifted with variety of forest landscapes from Lowland Dipterocarp Forest to Upper Montane Forest (Kumaran & Ainuddin 2006). According to Pahang State Forestry Department (2014), Cameron Highlands have approximately 3,876,365.76 hectare (ha) of Permanent Forest Reserve. With an area of 1,060 ha, Gunung Siku Forest Reserve is classified as an Upper Hill Dipterocarp forest as well as a tropical montane cloud forest that act as water catchment area that supports habitat for endemic and rare flora species (Peh et al. 2011, Kumaran & Ainuddin 2006). The trees on the upper montane zone are largely confined to members of the Coniferae, Ericaceae and Myrtaceae families (Perumal & San 1998).

Most of the cloud forests soils in Malaysia are derived from weather igneous or sedimentary rocks (Kitayama 1992, Proctor et al.1988). A similar formation was observed in the Gunung Siku Forest Reserve. However, uncontrolled forest opening for agriculture activities led the Pahang Forest Department to devise an execution plan called Cameron Highlands Dream that aimed to rehabilitate Cameron Highlands (FDPM 2014). According to FDPM Annual Report 2014, some of the activities outlined are law enforcement and re-greening the affected area via tree planting prioritizing illegally occupied area either within or outside the Permanent Reserved Forests (PRF).

Four species were planted in the study area in 2015 which are *Nageia wallichiana* (Podo Kebal Musang), *Agathis borneensis* (Damar Minyak), *Shorea platyclados* (Meranti Bukit) and *Gymnostoma sumatranum* (Rhu Bukit) with a 3m x 3 m length planting distance. These species were selected due to their suitability to the highland ecosystem and able to achieve optimum growth at Upper Hill Dipterocarp Forest (Noor et al. 2020, FDPM 2014).

In Malaysia, global warming may threaten the cloud forest biodiversity and these may lead to reforestation (Peh et al.2011). Increase in temperature during global warming may increase the rate of evapotranspiration and these dry conditions can cause the trees to wilt (Malhi et al. 2014). They concluded that the interaction between global climate change and regional deforestation had cause Amazonian forests vulnerable to large-scale degradation. However, the impact of climate on a forest ecosystem will vary depending upon regeneration and growth limiting factors (Bravo et al. 2008).

Temperature in Cameron Highlands increased throughout the year from 1981 until 2010 due to increase in anthropogenic activities such as land clearing for agriculture in Cameron Highland (Malaysian Meteorological Department 2016a). The dry season in Cameron Highlands starts at the beginning of the year while wet season with high precipitation occurs at the end of the year. According to Lewis (1998), ground surface temperatures were permanently increased when there permanent deforestation occurred due to transpiration. This activity cause adverse effects on water catchment areas, resulting in stream diversion, reduced water storage capacities of reservoirs and excessive accumulation of silt at the Sultan Abu Bakar hydroelectric dam (Barrow 2005). The soil is a natural body, contains mineral and organic components as well as physical, chemical and biological properties  2010).Chemical composition, mineral structure and the state of dispersion are important factors influencing soil properties (Kabata-Pendias  2010).

## MATERIALS AND METHODS

### Study site

This study was conducted at Compartment 5 in Gunung Siku Forest Reserve, Cameron Highlands with an area of 2.5 hectares in the year 2019. The area is ocated at  4°35'49.92" and 101°23'48.47" respectively (Figure 1). The area is characterized as steep land with consists of red-yellow podzolic soils with lithosols on acid to intermediate igneous rock.  Meteorological records indicated an average annual temperature between 17.2 to 18.5 ºC from 1969 to 2015 (Barrow et al. 2009, Malaysian Meteorological Department 2016b). Annual rainfall varies between 2,000 mm to 3,500 mm from year 1951 to 2015 (MMD 2016b) with western foothill areas receiving more precipitation than the mountainous areas.

The study area was primarily a forest reserve. It has however, been encroached upon by illegal logging and land clearing for agriculture activities. Since 2014, forest restoration to ensure native species survival was carried out to restore the area. The forest is also surrounded by recreational and agricultural areas, where water resources come from three main rivers of Bertam, Telom and Lemoi rivers. Extensive anthropogenic activities such as deforestation and land reclamation for agricultural activities and housing development have exposed the area to soil erosion (Gasim et al. 2009).

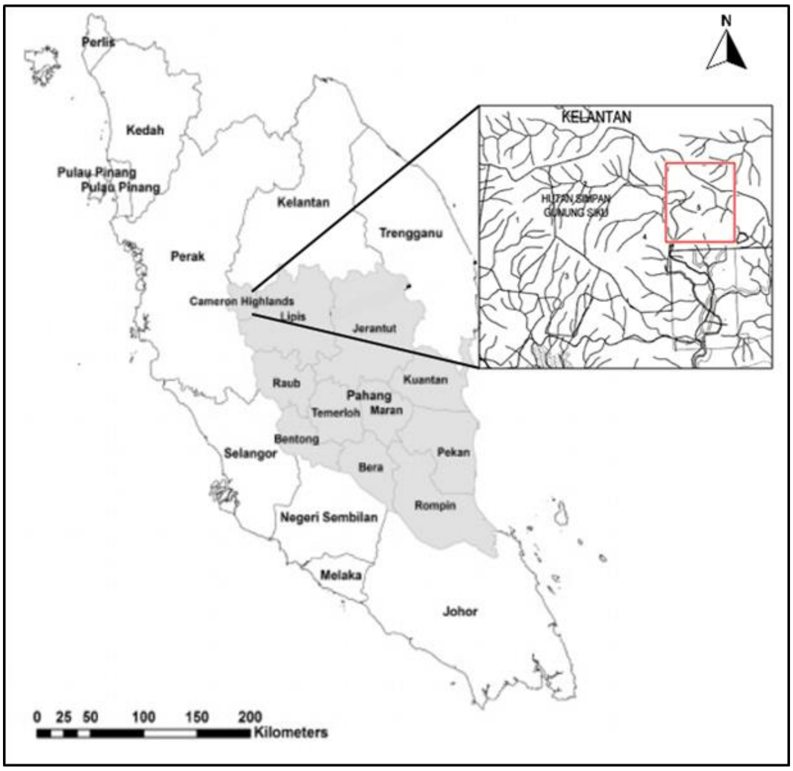


**Figure 1.** Study area at Compartment 5, Gunung Siku Forest Reserve

**Sample collection**

Four plots of 20m x 20m were established using stratified random in the area at altitude 1400-1500m a.s.l. Soil samples were collected in the middle of the plot diagonally at three sampling points at a distance of 5m. Data was collected in February and October 2021 with two different depths of 0–15 cm and 15–30 cm, respectively.

***Soil Physical Analysis***

The soil samples were homogenised, air dried, ground and sieved using 2.0 mm soil siever. In-situ measurement of soil pH and moisture content was carried out using Takemura Soil pH and Moisture Tester DM-15. The soil colour was identified using the Munsell Book of Color that provides a notation of soil color (Munsell 1994). The soil texture was analysed using modified method from Thien (1979).

*Soil Organic Matter Determination*

The soil samples were analysed using Loss-on-Ignition (LOI) procedure (Schulte & Hopkins 1996). All samples were placed into the crucibles and heated using furnace for two hours at 375 °C, then left to cool at room temperature for 30 minutes. Then, mass of the dried soil and crucible were weighed. The mass of organic matter and percentage of organic matter were determined using the equation below:

$$\text{Mass of organic matter (g)} = \frac{\text{(mass of soil and crucible before heating) (g)}}{\text{(final mass of crucible with burned soil) (g)}} \quad \text{(Equation 1)}$$

$$\text{Organic matter (\%)} = \frac{\text{(mass of organic matter) (g)}}{\text{(mass of soil before heat) (g)}} \times 100 \quad \text{(Equation 2)}$$

*Concentration of Metal Elements*

The soil samples were taken from the desiccator and sent for X-Ray Fluorescence (XRF) spectrometry analysis. Quantification of extractable cations and heavy metals from the soil samples made using the method of Imanishi et al. (2010).

*Statistical Analysis*

The pH, moisture content and soil organic matter were subjected to two factor analysis of variance (ANOVA) with replication at 95% confidence level with *p*-value more than 0.05.

Meanwhile, the concentration of heavy metals and extractable cations were subjected to two factor analysis of variance (ANOVA) without replication at 95% confidence level with *p*-value more than 0.05.

## RESULTS AND DISCUSSION

***Soil pH and Organic Matter***

Table 1 shows the result of soil moisture content and pH of the study area. The pH for soil samples collected from the study area can be classified as moderately acidic to neutral. A range of organic and inorganic acids and elements such as iron were likely to acidify the soil solution after acid hydrolysis starting from minerals or from the exchange complex (Pansu & Gautheyrou 2006). During dry season in February, the soil pH is rather acidic than in wet season in October. Binkley and Fisher (2013) reported that soil pH increased due to downslopes movement of bicarbonate, HCO. Carbonic acid ($H_2CO_3$) was formed between the reaction of $CO_2$ and water in the soil was further dissociates to $H^+$ that tended to react within the soil profiles and $HCO_3^-$ that leached in the form of cations such as $Ca^{2+}$, $Mg^{2+}$, $K^+$ and $Na^+$ (Binkley & Fisher 2013). This further accounted for slight higher soil pH in the dry season.

**Table 1.** Soil moisture content and pH of the study area

| Variable | February | October | p-value |
|---|---|---|---|
| Soil pH | 5.5 | 6.5 | 0.000 |
| Soil moisture (%) | 3.78 | 9.65 | 0.000 |
| Soil organic matter (SOM) (%) | 4.24 | 4.13 | 0.82 |

Higher moisture content is documented in February with value of 3.78% compared to 9.65% detected in October. Statistical analysis showed that different period have significant effect on the soil moisture content ($p>0.05$). Humidity is one of the contributing factors for soil moisture. High precipitation at the end of the year contributes to high soil moisture content, thus reducing the soil acidification as leaching process. According to Morse (2018), high annual rainfall amounts leached alkaline elements from the soil such as K, Ca and Mg, leaving acidic elements such as Mn, Al and H to replace the bases.

However, in February the area is exposed more to sunlight radiation as the climate become drier compared to October. The increased of light intensity and temperature may cause the rate of evapotranspiration to increase thus reducing the soil moisture content. Based on Nyberg (1996), slope shown to have a direct control on the solar irradiance which affect the evapotranspiration rate from the land surface. Tree roots helps to absorb water from the soil in order to recover water lost from transpiration and metabolic process (Binkley & Fisher 2013).

Over a period of nine months, SOM decreased from 4.24% to 4.13% with a slow rate of 0.012% per month (Table 1). According to Pansu and Gautheyrou (2006), SOM was greatly influenced by the local climate conditions. However, the statistical analysis obtained shows there was no significance evidence that the difference in time affect the percentage of SOM in the study area.

***Soil Texture***

Soil texture for at the study area can be classified as sandy clay loam with moderate coarse texture consist of 20 - 35% of clay, 70-100% of sand, 65-80% of silt and it formed ribbons with a length between 1 to 2 inches (Binkley & Fisher 2013). According to Ramade (1981), soil texture governs most of the properties of the soil such as its permeability and capacity to retain water, store nutrients in the clay-humus complex, withst and mechanical changes and to support permanent plant cover (Osman 2013).

***Soil Colour***

The soil colour from the samples is categorized as dark brown. The darker shades of soil contribute by clay mineral and it is the indication of the richness of soil organic matter of the study area (Schroeder & Kingston 2000). Soils in the study area is identified as podzols type, appears as yellowish brown, brown or reddish brown in colour due to domination of goethite with Munsell hue of 7.5YR. Yellow, brown and red hues soils normally indicate aerobic conditions and synonymous with high oxygen inputs and rarely occurring water saturation.

### *Concentration of Metal Elements*

*Macronutrients*

Magnesium is an essential macronutrients element for plant growth (Kabata-Pendias 2010, Marschner 2002). Table 2 shows the concentration of macronutrients in the study area. However, the different months did not show any significant difference in Mg concentrations. The value of Potassium (K) in February and October also did not show any significant difference. K helps to regulate water content via closing and opening of stomata (Jones 2012).

**Table 2.** The concentration of macronutrients in the study area

| Element | February (mg/kg) | October (mg/kg) | p-value |
|---|---|---|---|
| Magnesium (Mg) | 1.0 | 1.2 | 0.75 |
| Potassium (K) | 7.37 | 7.19 | 0.48 |
| Plumbum (Pb) | 0.14 | 0.15 | 0.15 |
| Copper (Cu) | 0.12 | 0.13 | 0.14 |
| Zinc (Zn) | 0.16 | 0.20 | 0.15 |

The Pb content value did not show significant difference between the months. Pb is the most readily pollutant that can accumulates in soils and sediments through pedogenic or antropogenic sources (Jones 201 Sharma & Dubey 2005). Thus, it is not needed by plant in growth development. The values of Cu and Zn in both the dry and wet periods also show no significant difference. All micronutrient elements did not exceed the Regulatory Limits for Heavy Metals as stated by USEPA. This indicated that these elements acts as essential elements for the plants and did not contaminate the soil or threaten the plant growth

Based on the current assessments, the soil condition in the study area is moderately acidic to neutral pH ranges, moderately coarse textured with strong brown colour, and have optimal SOM presence. The soil at Compartment 5 in Gunung Siku Forest Reserve is fertile and for plant growth of the species planted which is characterized by sufficient levels of macronutrients as well as low amounts of trace metals.

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