# Variation of Soil Physical Properties of Kanneliya and Sinharaja Tropical Lowland Rainforests of Sri Lanka Along an Altitudinal Gradient

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**Abstract** - Increasing deforestation leads to reduce climate change mitigation capacity of tropical lowland rainforests (TLRFs) in Sri Lanka. For efficient forest conservation, knowledge of both above- and below-ground characteristics of TLRFS is required. Up to date, above-ground information sufficiently available but below-ground details are scarce. Therefore, this study was carried out to investigate soil physical properties by selecting two important TLRFs: Kanneliya (KDN) and, Sinharaja-Pitadeniya (PTD). Four permanent sampling plots (PSPs) of one ha ($KDN_1$, $KDN_2$, $PTD_1$ and $PTD_2$) were established. Five composite soil samples from each PSP up to 25 cm were collected. Bulk density, porosity, volumetric water content (VWC), field capacity (FC), permanent wilting point (PWP) and available water content (AWC) were determined. Soil aggregate stability was measured by using Le Bissonnais method following (i) fast wetting (FW), (ii) slow wetting (SW) and (iii) mechanical breakdown (MB). Data were statistically analysed. Measured parameters were significantly ($P<0.05$) different among PSPs except bulk density, porosity, FC and AW. Bulk density, porosity and VWC ranged between 1.03-1.39 Mg $m^{-3}$, 0.48-0.61% and 8.93-16.11%, respectively, while FC and PWP were between 34.16-48.75% and 10.26-14.75%, respectively. Aggregate stability ranged between 0.89-1.38 (FW), 0.78-1.43 (SW) and 0.75-1.34 (MB). The size of major aggregate fraction was >2 mm for FW and SW while MB was >0.25 mm. Most stable and least stable soil aggregates were found in $PTD_2$ and $KDN_2$, respectively. Overall, with increasing altitude, soil porosity and VWC increased while bulk density, FC and PWP decreased. A clear relationship was not observed between altitude and aggregate stability.

***Keywords: Tropical lowland rainforest; soil below-ground properties; soil physical properties; forest conservation***

## I. Introduction

Tropical rainforests (TRFs) are one of the warmest, wettest and oldest woodland Biomes on the earth and are demarcated by high precipitation (>2,500 mm), dense biodiversity and continuous canopies of evergreen trees [1]. In Sri Lanka, the majority of TRFs belong to tropical lowland rainforests (TLRFs), for example Kanneliya (KDN) complex and Sinharaja Biosphere Reserve [2]. During photosynthesis, the rainforest vegetation captures a considerable amount of $CO_2$ and store it in forest soils and biomass [3]. The reduction of atmospheric $CO_2$ is directly involved in climate change mitigation. Importantly, below-ground soil physical properties exert a significant influence to ensure the ecosystem roles of above-ground vegetation [4]. Currently, Sri Lankan TLRFs ecosystem is under serious threat due to rapid deforestation, thus reducing the efficiency and effectivity of their ecosystem services. Conservation and restoration of TLRFs are essential, but are constrained by a scarcity of information on above-ground forest and below-ground soil properties of TLRFs and their dynamics. In comparison to above-ground information, availability of information on below-ground properties is particularly scarce. In order to fill this gap, researching is needed elucidating the variation of below-ground soil properties of TLRFs. Therefore, the objective of this study was to investigate soil physical properties, selecting two important TLRFs, Kanneliya and Sinharaja-Pitadeniya (PTD), Sri Lanka as an initial step to expand the level of understanding about them.

## II. Materials And Methods

### A. Sample collection and preparation

Soil samples were collected from four permanent sampling plots (PSPs): two from the KDN complex ($KDN_1$ - 117, $KDN_2$ - 174 m asl) and two from PTD ($PTD_1$ - 509, $PTD_2$ - 618 m asl). Each PSP was one ha in size and soil samples were collected from five representative places of a PSP up to 25 cm.

### B. Analysis of soil physical properties

Soil physical properties were measured by conducting field-level measurements and a series of laboratory analyses. Soil bulk density, porosity, volumetric water content (VWC), field capacity (FC), permanent wilting point (PWP) and available water content (AWC) were measured using standard methods. Soil aggregate stability was determined according to the Le Bissonnais method [5] following three treatments: (i) fast wetting (FW), (ii) slow wetting (SW) and (iii) mechanical breakdown (MB). The following equation was used to determine aggregate stability based on the mean weight diameter (MWD) of soil particles.

$$MWD = \sum_{i=1}^{n} XiWi \quad (1)$$

where $Xi$ is the mean weight diameter (mm) of each size fraction and $Wi$ is the proportion of the total sample mass in the corresponding size fraction

### C. Data analysis

All measured data were subjected to analysis of variance (ANOVA) using the General Linear Model and mean separation was conducted using Duncan's New Test.

## III. Results And Discussion

### A. Soil physical properties

Measured parameters were significantly ($P<0.05$) different among PSPs except for bulk density, porosity, FC and AWC. Except for soil aggregate stability, variations of all other physical parameters are presented in Table 1.

Table 1: Variation of soil bulk density, porosity, VWC, FC, PWP and AWC values of measured PSPs.

| Location | Bulk density (Mg $m^{-3}$) | Porosity (%) | VWC (%) | FC (%) | PWP (%) | AWC (%) |
|---|---|---|---|---|---|---|
| KDN 1 | 1.39± $0.17^{a}$ | 47.65± $6.46^{b}$ | 8.93± $1.91^{c}$ | 48.75± $5.04^{a}$ | 14.75± $1.72^{a}$ | 33.99± $3.37^{a}$ |
| KDN 2 | 1.25± $0.19^{ab}$ | 53.01± $7.21^{ab}$ | 14.02± $2.16^{ab}$ | 39.24± $10.79^{a}$ | 11.15± $1.23^{bc}$ | 28.08± $6.76^{a}$ |
| PTD 1 | 1.22± $0.27^{ab}$ | 54.07± $5.01^{ab}$ | 11.13± $2.98^{ab}$ | 41.17± $10.79^{a}$ | 13.04± $1.35^{ab}$ | 28.13± $10.75^{a}$ |
| PTD 2 | 1.03± $0.23^{b}$ | 61.25± $8.62^{a}$ | 16.11± $5.82^{a}$ | 34.16± $6.38^{a}$ | 10.26± $0.88^{c}$ | 21.31± $4.49^{a}$ |

The highest bulk density values were recorded in $KDN_1$ whereas the lowest was determined in $PTD_2$ (Table 1). Even though bulk density was not significantly ($P>0.05$) different, a gradual decrease was observed with increasing altitude. The bulk density value higher than 1.75 Mg $m^{-3}$ could restrict root penetration [6] but none of the measured values exceeded this limit in all PSPs. Soil porosity gradually increased with increasing altitude. The highest soil porosity was shown in $PTD_2$ whereas the lowest was in $KDN_1$ (Table 1). In the rainforest ecosystem, around 50% of average soil porosity is needed for proper soil oxygen circulation and also for ensuring potential plant growth [4]. All calculated soil porosities of the above PSPs were close to this value, except in $PTD_2$ (Table 2). Thus, in these TLRFs vegetation is expected to be in its potential growth status. Both bulk density and porosity values are influenced by soil texture, clay content, water and aeration status of the particular soil [6]. VWC was significantly ($P<0.05$) different among different PSPs and a gradual increase was observed with the increase in altitude. The highest VWC was recorded for $PTD_2$ and the lowest was observed in $KDN_1$ (Table 2). VWC is affected by soil porosity and highly porous soils have more capacity to store water than compacted soils [4].

PWP was significantly ($P<0.05$) different among different PSPs whereas FC and AWC content did not show a significant ($P>0.05$) difference. The highest FC, PWP and AW content values were recorded in $KDN_1$: 48.75±5.04, 14.75±1.72 and 33.99±3.37%, respectively, whereas the lowest values were in $PTD_2$: 34.16±6.38, 10.26±0.88 and 21.31±4.49%, respectively. The observed variation of FC, PWP and AWC might be due to the differences in soil texture, organic matter decomposition and wettability of soil materials [7] of each PSP. Wider knowledge of soil FC, PWP and AWC content of TLRFs soil is essential as these parameters indicate soil water availability of TLRFs soils for the growth and development of vegetation.

### B. Soil aggregate stability

Variation of aggregate stability of selected PSPs, as measured following Le Bisonnais method [5] is presented as the mean weight diameter (MWD) of the soil aggregates in Figure 1.

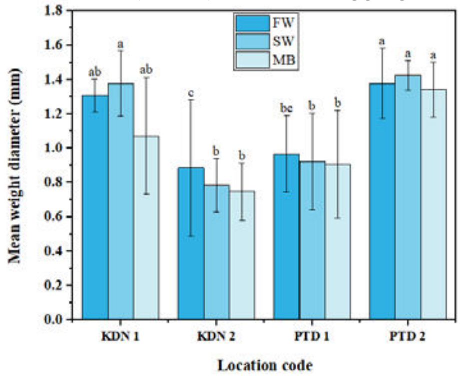


Fig. 1. Variation of soil aggregate stability of selected PSPs, as determined following Le Bisonnais method

MWD values for all three treatments were significantly ($P<0.05$) different among different PSPs and the values ranged between 0.89-1.38 in FW, 0.78-1.43 in SW and 0.75-1.34 in MB. The highest soil aggregate stability values for all treatments were recorded in $PTD_2$ whereas the lowest values were in $KDN_2$ (Figure 1). The size of the major MWD fraction was >2 mm for FW and SW treatments of all PSPs; for MB, it was >0.25 mm. The relationship between aggregate stability and altitude is unclear. Based on MWD values, soil aggregate stability is categorized into five classes and accordingly, soils with >2 MWD are considered highly stable aggregates whereas aggregates <0.4 MWD are very unstable aggregates [7]. The most stable soil aggregates were found in $PTD_2$. All PSPs, except $KDN_2$, consisted of medium to stable soil aggregates for all the treatments. In $KDN_2$, soil aggregates in FW were stable but for SW and MB, soil aggregates were unstable. Variation of soil aggregate stability is caused due to the variation in soil texture, organic matter content, type of clay mineral and microbial activities [8]. Considering the TLRF soils, alteration of aggregate stability is a rare phenomenon under undisturbed conditions [4]. Investigation of aggregate stability of TLRFs soils is a key component in forest management. Soil aggregate matrix is linked with soil pore size distribution and participates in the regulation of the moment of soil air and water flow [8]. The stability level of soil aggregates ensures continuous flow of air and water into plant roots. Therefore, aggregate stability is considered as a key indicator of soil quality and health in the TLRFs ecosystems.

## IV. Conclusion

Through the study, variation of soil physical properties with elevation was determined. When compared with standard interpretation tables, most measured soil parameters were found to be within appropriate ranges for sustaining growth and ecosystem functions of TLRFs vegetation. Overall, measured soil physical properties, especially soil aggregate stability can be considered as an ideal indicator for TLRFs soil management. It is recommended to establish relationships between these soil physical characteristics and already available above-ground vegetation characteristics of these TLRFs for establishing better conservation strategies.

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