Mountainous Forest Soil Water Absorptability for Increasing Summer Water Capacity of Kaeng Krachan Storage Dam

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Abstract

Kaeng Krachan National Park has an area of approximately 2,914.70 square kilometers. There is a fertile forest, the forest watersheds of the Phetchaburi River. During the summer, the reservoir contains only 122.11 million cubic meters of water per year resulting in drought and water shortage problems during the rainy season from winter to summer. Therefore, it is worth studying the soil moisture for the land use, i.e., moist evergreen forest areas and mixed deciduous forest area, and comparing soil moisture in each forest type including finding the soil moisture in the height of the water in the soil sub-watershed in Ban Pratu Phi area Kaeng Krachan National Park Phetchaburi Province.

The results showed that the soil water capacity in percentage by volume at the soil depth of 0-15 cm in the mixed deciduous forest area is an average of 26.54 percent. While the mean moist evergreen forest area was an average of 25.91 percent by volume, and a soil depth of 15-30 cm in mixed deciduous forest area has an average of 24.92 percent by volume. The mean moist evergreen forest area was equal to 24.48 percent by volume. Both forest types and all soil depths were not significantly different ($p>0.05$) and soil moisture when accounted for the height of water. In the mixed deciduous forest area in the range of 0.265-0.249 cm, the moist evergreen forest area in the range of 0.259-0.245 cm, it can be seen that the soil moisture varies according to the soil cover factor, percentage of clay, and rainfall. From the study on soil moisture in Kaeng Krachan National Park, Phetchaburi Province, it can be used as a guideline for water resource management in the summer for the allocation of water to be beneficial and sufficient for people's needs in using water for agriculture and consumption.

Keywords: soil water capacity, moist evergreen forest, mixed deciduous forest

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Introduction

Soil moisture or soil water is part of the water that comes from rain to the soil surface, some water is adsorbed and infiltrated between soil particles, moistening and partially seeping into groundwater. If it rains when the soil is unable to absorb water, the water will be drained into the river. The factors related to soil moisture include: Rainfall, Land cover, and Topography (Somporn and Kasem, 1973) During the rainy season, water in streams came from surface runoff, and summer water in the particulates will be utilized for evapotranspiration which will reduce the amount of soil moisture in the summer due to insufficient water. The soil, therefore, acts like a reservoir of water when it comes to summer in storing water, allowing plants to use this water for growth and draining water into the lower area, so as to achieve the purpose of watershed management. To obtain sufficient water to meet the needs in the summer and not exceeding to cause flooding in the rainy season, the soil in the watershed area must retain moisture sufficiently in the rainy season and released into streams in an amount sufficient to meet the needs of users throughout the year without causing severe flooding or water runoff.

Sup-watershed in Baan Pratu Phi Kaeng Krachan National Park, Phetchaburi Province is a sup-watershed of the Phetchaburi watershed and an area upstream that can retain water in the soil and nourish the streams in the summer. However, at the present, soil moisture has not been studied. Therefore, the objective of this study is to investigate the soil moisture of moist evergreen forests and mixed deciduous forest including to find the soil moisture in the height of the water in the soil sub-watershed in Ban Pratu Phi area, Kaeng Krachan National Park, Phetchaburi Province.

Material and Method

1. Determination of soil sampling points

Set up soil sampling in mixed deciduous forest and moist evergreen forest at sub-watershed Ban Pratu Phi area, Kaeng Krachan National Park Phetchaburi Province, collect according to the type of forest; 3 points per forest. At the altitude of the area of 100, 200, and 300 meters from mean sea level, a total of 6 points, each with 2 levels of soil collection, 0-15 and 15-30 centimeters, as shown in Figure 1.

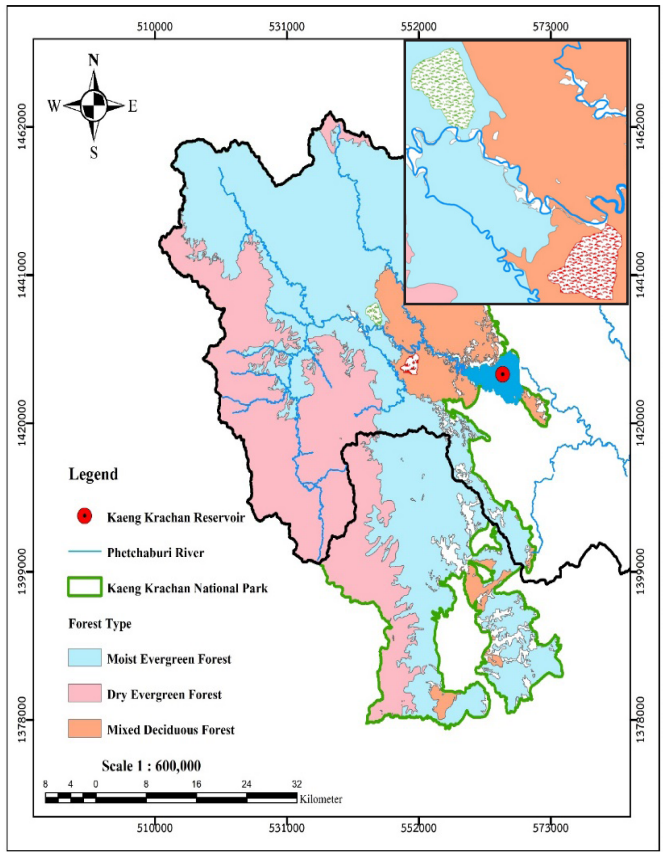

Figure 1. Soil sampling station at sub-watershed Ban Pratu Phi area

2. Soil Sampling

The soil sampling was conducted 4 times, every month from March to June 2021. The undisturbed soil sample was collected using a soil core sampler. For analysis at 2 depths; 0-15 and 15-30 centimeters and disturbed soil sample was collected by the composite sample method. An analysis is conducted at 2 depths; 0-15 and 15-30 centimeters, from the soil surface. The soil samples at both levels of each type of forest were mixed together, 1 kg of each sample was placed in a plastic bag and the storage location was specified for further laboratory analysis.

3. Soil Sample Preparation

3.1 Take an undisturbed soil sample. Weigh before baking and bake at a temperature of 105-110 ℃ not less than 24 hours until completely dry and until the weight does not change or obtain constant weight for further analysis of bulk density.

3.2 Take a disturbed soil sample. Dry in the shade (air dry) and grind with a mortar. Then sift using 2 millimeters sieve and separate gravel, rubble, mineral, and litter for further analysis of soil texture and soil moisture.

4. Data Analysis

4.1 Soil texture analysis is submitted for analysis at the Department of Soil Science, Faculty of Agriculture, Kasetsart University.

4.2 Soil bulk density; BD, by taking soil samples without damaging the structure. Weigh before baking and bake at a temperature of 105-110 ℃ for not less than 24 hours until completely dry until the weight does not change or obtain constant weight for further analysis of soil density as shown in equation 1.

$$BD = \frac{M_s}{V_t} \quad (1)$$

Where BD = Bulk density (grams per cubic centimeter)

M_s = Dry soil mass (g)

V_t = Volume of soil (cubic centimeter)

4.3 Soil moisture by weight; P_w, calculate soil moisture by weight as shown in equation 2.

$$P_w = \frac{M_w - M_d}{M_d} \times 100 \quad (2)$$

Where P_w = Percentage of moisture by weight of soil when soil is completely dry.

M_w = Weight of wet soil (g)

M_d = Weight of dry soil (g)

4.4 Soil moisture by volume; P, Percentage soil moisture by volume can be obtained from soil bulk density (BD) multiplied by moisture by weight (PW) is shown in equation 3.

$$P_v = BD \times P_w \quad (3)$$

Where P_v = Percentage soil moisture by volume.

BD = Bulk density

P_W = Soil moisture by weight, by the weight of the soil when the soil is completely dry.

4.5 Calculate the height of the water as in equation 4 as follows.

$$h = \frac{P_w \times H}{100} \quad (4)$$

Where h = Height of soil moisture (centimeter)

P_w = Percentage of moisture by weight of soil when soil is completely dry

H = Soil depth (centimeter)

4.6 Compare the difference in soil moisture at each depth between the moist evergreen forest area and mixed deciduous forest area using t-test method.

Results and Discussion

The study of soil moisture at each depth of the moist evergreen forest and mixed deciduous forest in Kaeng Krachan National Park Phetchaburi Province, the results shown in Table 1, and can be discussed as follows:

Soil Texture

It can be seen that the soil texture of each forest type has different soil texture. The upper soil texture of the moist evergreen forest is sandy clay loam and the mixed deciduous forest area is sandy loam. In addition, it was found that the lower soils of the study area had sandy clay loam, similar to the study of Somsak (1977) which found that the soil texture of the moist evergreen forest was sandy clay loam and sandy clay to clay. It is a sandy clay loam. Mixed deciduous forest area according to a study by Soonthorn (2015), it was found that the topsoil of the mixed deciduous forest area has sandy loam and sandy clay loam deep into clay loam and sandy loam. The subsoil has a soil texture of sandy clay and clay. And in the study of Amonrat (2001) found sandy loam and sandy clay loam and the forest soils have a

sandy loam texture. And in the study of Amonrat (2001) found a sandy loam and sandy clay loam and the forest soils have a sandy loam texture (Khybri, 1965).

Table 1. Soil texture, Bulk density of each soil level in each forest type at Ban Pratu Phi Kaeng Krachan National Park, Phetchaburi.

Forest Types	Soil Dept (cm.)	Soil Particle			Soil Texture	Bulk Density (g/cm^3)
		% sand	% silt	% clay		
Mixed Deciduous Forest	0-15	62	21	17	SL	1.29
	15-30	56	20	24	SCL	1.32
Moist Evergreen Forest	0-15	54	20	26	SCL	1.05
	15-30	48	26	26	SCL	1.15

Remark: SL = sandy loam, SCL = sandy clay loam

Bulk Density; BD

The average bulk density in the moist evergreen forest area at a soil depth of 0-15 cm, the mean was 1.05 g/cm^3. As for the mixed deciduous forest area, the mean was 1.29 g/cm^3. The average bulk density in the moist evergreen forest area at soil depth of 15-30 cm, the mean was 1.15 g/cm^3. As for the mixed deciduous forest area, the mean was 1.32 g/cm^3. It was found that moist evergreen forests and mixed deciduous forest bulk density tend to increase with soil depth.

Considering the depth, the total density increased with the depth (Hassett and Banwart, 1992; Wenzel et al., 1998), similar to that of the hill evergreen forest. (Permsak, 1979). Dry evergreen forest and dry dipterocarp forest (Aksornkoae, 1971), and moist evergreen forest. (Chaiwat, 1989). Bulk density increases with this depth depending on the increased amount of clay and the reduction of organic matter (Aksornkoae, 1971). The topsoil is usually less dense than the subsoil due to the high level of organic matter produced by the leaf drop. When considering each area, it was found that the soil of the moist evergreen forest had a higher total density than the soil of the mixed deciduous forest because the bulk density of soil is related to organic matter and clay (Aksornkoae, 1971). This corresponds to Boonrit (1982) who studied the total density of soil at depths of 0-5, 5-10, and 50-70 centimeters which found that the values were not different except for the ground (depth of 20-30 cm). The total density of this soil layer is uncertain and the total bulk density of soil at depth (50-70 cm). The conditions of moist evergreen forests, rubber plantations, coffee plantations, and palm plantations were most similar. And it is in the same way as the moist evergreen forest area. At a depth of 0-30 centimeters, the values were between 1.18-1.44 g/cm3 (Chaiwat, 1989). In the area of mixed deciduous forest at a depth of 0-30 centimeters, the values were between 1.03-1.34 g/cm3 (Amonrat, 2001) as shown in Table 1.

Soil Moisture

Soil moisture in the moist evergreen forest area at the soil depth 0-15 cm was averaged equal to 26.15 percent by volume. As for the mixed deciduous forest area, the soil moisture average was 26.94 percent by volume. Soil moisture in the moist evergreen forest area at a soil depth of 15-30 cm was averaged 24.74 percent by volume. The average mixed deciduous forest area was 25.15 percent by volume. The soil moisture of both types of forests and depth has no statistically significant differences ($p>0.05$).

Soil moisture in the mixed deciduous forest area was higher than in the moist evergreen forest area because the mixed deciduous forest area has a higher percentage of clay than those in the moist evergreen forest where clay particles have a good water-holding capacity (Miller, 1977). As a result, soil water capacity in the mixed deciduous forest was higher than in the moist evergreen forest with less clay content. In addition, the upper canopy of the moist evergreen forest has spaces

that are generally scattered. The environment generally has relatively few groundcovers and the ground cover plants help to block the heat from the sun's rays and reduce the evaporation of water from the soil surface. And relatively less soil cover results in higher evaporation transpiration. Also, in the summer is high temperature, and strong sunlight, causing high evaporation. As a result, the moist evergreen forest area has less soil moisture than the mixed deciduous forest area. In the mixed deciduous forest, the ground is covered with grass that keeps the topsoil moist even during the summer months. However, the factors of soil moisture are soil cover and rain which is still another very important factor in soil moisture. (Lecturer, Department of Soil Science, 1998).

Considering each soil depth, it was found that both forest areas had lower soil moisture levels. This may be due to the decrease in organic matter of the lower soil. As a result, the soil water capacity in the lower soil was reduced as shown in Table 2. In summer, the decrease in soil water capacity tends to decrease quite regularly. Soil moisture has not changed much. However, at depths of 0-15 and 15-30 centimeters, most of them change due to rainfall on certain days. It can be seen that the soil moisture varies largely depending on the amount of precipitation received by the soil surface (Kasem and Permsak, 1979; Sakurai et al., 1991; Fig. 3). Weera and Thammanoon, 1993), for example, the soil water capacity of the Doi Pui hill evergreen forest. Tropical wetlands in abandoned farmland and pine forest plantations of different ages at the soil surface at a soil depth of 0-15 cm showed more daily changes than at other levels. Because the surface receives rainfall that falls directly to the ground. When it rains at the first stage, the soil water capacity increases rapidly. For soil moisture at the soil depths of 15-30, 30-60, and 60-90 cm, the change in moisture content was similar (Mayer and Anderson, 1952; Table 1). Permsak, 1979). When entering the dry season, it was found that the soil moisture of the moist evergreen forest at the soil depth of 15-30 cm had the lowest soil moisture with a slightly lower value at a depth of 0-15 cm. Because both at soil depths 0-15 and 15-30 cm, there is more moisture loss through evaporation than those in other depths. And at a soil depth of 15-30 cm, it is a depth that loses moisture more rapidly than other areas (Shoji et al., 1977), resulting in the lowest soil moisture. Table 2 shows soil moisture and soil water level in each month and forest type at Ban Pratu Phi and Ban Bang Kloy.

Table 2. Soil moisture and soil water level each month and each forest type in Ban Pratu Phi Kaeng Krachan National Park, Phetchaburi

Month	Rainfall (mm.)	% Moisture by volume (P_v)				Soil water level (cm.)			
		MEF		MDF		MEF		MDF	
		0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30
March	24	22.01	22.90	19.43	21.26	3.301	3.435	2.914	3.190
April	27	22.35	18.82	23.60	21.48	3.353	2.823	3.541	3.222
May	109	29.56	30.92	27.65	27.03	4.434	4.638	4.148	4.054
June	15	29.73	25.29	35.48	29.91	4.460	3.794	5.322	4.487
Total	175	103.65	97.94	106.17	99.69	15.548	14.691	15.925	14.953
Average/15 cm.	-	25.91	24.48	26.54	24.92	3.887	3.673	3.981	3.738
Average/soil 1 cm.	-	-	-	-	-	0.259	0.245	0.265	0.249

Remark: MEF = Moist evergreen forest, MDF = Mixed deciduous forest

Soil water height in the sub-watershed area, Ban Pratu Phi Branch Kaeng Krachan National Park Phetchaburi Province.

The study found that in moist evergreen forest and mixed deciduous forest areas at a depth of 0-15 cm, soil water elevation was the lowest in March (3.301 and 2.914 cm) and soil water accumulation increased with the highest in June (4.460 and 5.322 centimeters). At a depth of 15-30 cm, the height of soil water in mixed deciduous forests increased from March (3.190 cm) to June at the highest value (4.487 cm) with a fixed value. The highest value in May was 4.638 cm and decreased in June (3.794 cm). The change in soil water content is mainly caused by precipitation in May that increased and in June the precipitation decreased significantly. As a result, the soil water level in the soil changes.

It can be seen that the soil moisture of the evergreen and mixed deciduous forests can be calculated as the height of the water in each soil depth. It was found that the water content of the soil in the mixed deciduous forest at the soil depth of 0-15 cm had the highest soil water content of 15.925 cm when accounted for the height of water per 1 cm of soil thickness equal to 0.265 cm. For mixed deciduous forests and moist evergreen forests lower soil levels, the soil water capacity was 15.548, 14.953, and 14.691 centimeters, respectively. It was calculated as the height of water per 1 cm of soil thickness equal to 0.259, 0.249, and 0.245 cm, respectively, as shown in Table 2. There was no difference in soil water in both area. However, in mixed deciduous forest areas, the amount of water in the soil is higher than that of the moist evergreen forest at both levels of soil and it was found that the soil water content was higher when entering into May in both areas. The results of the study found that the value was similar to the mixed deciduous forest area. At the Mae Klong River Basin Research Station, Kanchanaburi Province, the water height per 1-cm soil thick in summer was in the range between 0.23-0.27 cm (Amonrat, 2001). But it is more valuable in the Huai Khem watershed (Dry evergreen forest, Forest Plantation). Soil water capacity in areas with an average monthly water height of 239.45 millimeters or 0.24 centimeters per 1 centimeter of thick soil height is the same as the height of the Huai Ta watershed soil (area with natural vegetation replacement and planting area with some dry evergreen forest and the soil of the Huai Khok Phet watershed (natural deciduous dipterocarp area)) which has soil water capacity with an average monthly water height of 134 and 113.60 millimeters, representing the height of water per 1-centimeter soil thick for 0.13 and 0.11 centimeters (Somkid, 1994).

Comparison of soil moisture difference between moist evergreen forest and mixed deciduous forest and at soil depth 0-15 and 15-30 centimeters by using t-test.

The analysis of soil moisture comparison data between moist evergreen forest and mixed deciduous forest and at soil depths of 0-15- and 15-30 centimeters using t-test statistical methods were not statistically significant at a 95 percent confidence level (Table 3).

Table 3. Soil moisture difference between moist evergreen forest and mixed deciduous forest at soil depths of 0-15 and 15-30 centimeters

Comparative Factors		t-value	Sig.
1. forest type	moist evergreen forest mixed deciduous forest	0.643^{ns}	0.427
2. soil dept	0-15 centimeters 15-30 centimeters	0.294^{ns}	0.093

Remark: ns = not statistically significant at the 95 percent confidence level ($p>0.05$)

Conclusion

From the study of soil moisture in the moist evergreen forest area and mixed deciduous forest sub-watershed in Ban Pratu Phi area Kaeng Krachan National Park, Phetchaburi Province in the study area for 2 types of forests including moist evergreen forest areas and mixed deciduous forest area at the depths of 0-15 and 15-30 centimeters from March to June 2021, the results showed that the soil texture of the moist evergreen forest at a soil depth of 0-15 cm was sandy loam, at the soil depth of 15-30 cm was sandy clay loam. The average bulk density in the moist evergreen forest area at a soil depth of 0-15 cm was 1.29 g/cm3, and at a soil depth of 15-30 cm was 1.32 g/cm3. Soil moisture in the moist evergreen forest area at a soil depth of 0-15 cm in March, April, June, and May were 22.01, 22.35, 29.56, and 29.73 respectively and at a soil depth of 15-30 cm in March, April, June, and May were 22.90, 18.82, 30.92 and 25.29 respectively. The elevation of soil water in the moist evergreen forest at a soil depth of 0-15 cm in March, April, June, and May were 3.301, 3.353, 4.434, and 4.460 respectively. And at a soil depth of 15-30 cm in March, April, June, and May were 3.435, 2.823, 4.638, and 3.794 respectively. While the soil texture of a mixed deciduous forest area at a soil depth of 0-15 and 15-30 cm was sandy clay loam. The average soil density in the mixed deciduous forest at a soil depth of 0-15 cm was 1.05 g/cm3, and at a soil depth of 15-30 cm was 1.15 g/cm3. Soil moisture in the mixed deciduous forest at a soil depth of 0-15 cm in March, April, June, and May were 19.43, 23.60, 27.65, and 35.48 respectively. And at soil depth 15-30 cm in March, April, June, and May were 21.26, 21.48, 27.03, and 29.91 respectively. The elevation of soil water in the mixed deciduous forest at a soil depth of 0-15 cm in March, April, June, and May were 2.914, 3.541, 4.148, and 5.322 respectively. And at a soil depth of 15-30 cm in March, April, June, and May were 3.190, 3.222, 4.054, and 4.487 respectively.

Comparing the soil moisture of both forest types and at the depths of 0-15 and 15-30 centimeters was not statistically significant different at the 95 percent confidence level ($p>0.05$). As a result, the soil water absorption capacity of forests in the Kaeng Krachan national park during the dry season was not different. Both forest areas had lower soil water capacity due to the increased bulk density with depth causing water to seep into the soil more slowly, so the upper soil has higher soil water capacity than the lower soil.

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