A Comparative Study of Soil Fertility between Mesa and Foothill Sides in Phu Sing hill , Sahatsakhan District, Kalasin Province

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Abstract

This research investigates the spatial variability of soil chemical fertility within the unique geological setting of Phu Sing hill , Sahatsakhan District, Kalasin Province. The study aims to characterize and compare the fertility status and chemical composition of soils located in two sides of the hill zones the flat-topped Mesa side and the Foothill side . Understanding these chemical distinctions is crucial for developing site-specific nutrient management strategies and leaching processes in the area.The statific analysis yielded significant differences between the two topographical zones. regarding soil reaction, both areas exhibited Potassium (K) conditions, though the Mesa soil presented a slightly higher pH of 7.54, compared to the Foothill soil, which had a pH of 7.22. This pH range suggests that while both soils are generally suitable for cultivation, the availability of certain micronutrients might be limited, necessitating careful management.A detailed assessment of basic nutrients (N-P-K) revealed a consistent trend where the Foothill topography demonstrated superior fertility levels. Specifically, the Foothill soil contained significantly higher concentrations of all major nutrients: Nitrogen (N) at 28.60 mg/kg, Phosphorus (P) at 112.80 mg/kg, and Potassium (K) at 105.60 mg/kg. In contrast, the Mesa soil showed comparatively lower nutrient reserves, with Nitrogen levels at 12.80 mg/kg, Phosphorus at 76.60 mg/kg, and Potassium at 69.00 mg/kg.The results indicate that the Foothill area show a richer nutrient accumulation, because due to organic matter deposition and leaching processes from higher elevations. Notably, Phosphorus levels in both areas are exceptionally high, particularly in the Foothill zone. Consequently, agricultural planning for the Mesa area should increase nitrogen and potassium enrichment to solve the fertilities problem, whereas management in the Foothill area should focus on maintaining nutrient balance and monitoring potential phosphorus run-off.

Keywords: Soil Chemical Fertility, Phusing hill

Introductions

Soil fertilityis a pivotal determinant of agricultural productivity and ecosystem sustainability, particularly in regions where geological structures significantly influence pedogenesis (soil formation). Among the critical indicators of soil health, chemical properties specifically soil reaction (pH) and primary macronutrients such as Nitrogen (N), Phosphorus (P), and Potassium (K) play a fundamental role in governing plant growth and yield potential. However, these chemical attributes are not spatially uniform; they are subject to high variability driven by topographical factors. In complex landscapes, the differences in elevation, slope, and landform can drastically alter nutrient accumulation, leaching processes, and organic matter distribution.

Phu Sing hill, located in the Sahatsakhan District of Kalasin Province, Thailand, represents a unique geological setting characterized by a "Mesa" side . A Mesa is an isolated, flat-topped hill with steep sides, standing distinctly above a surrounding plain. This specific geomorphology creates two contrasting environments: the elevated flat plateau (Mesa top) and the depositional zones at the base (Foothill). While the geological uniqueness of Phu Sing is well-recognized as a geo-heritage site, there is a lack of comprehensive research comparing how this distinct topography affects the chemical fertility of the soil used for local agriculture.

Understanding the chemical disparities between the Mesa top and the Foothill areas is essential for precision agriculture. The processes of erosion and surface runoff naturally transport sediments and nutrients from higher elevations to lower slopes, potentially creating a fertility gradient. Therefore, soil management strategies applied to the Mesa top may need to differ significantly from those applied to the Foothill to achieve optimal crop performance.

This research aims to investigate and compare the soil chemical fertility between the Mesa and Foothill topographies in the Phu Sing area. By utilizing precise chemical analysis to assess pH levels and N-P-K concentrations, this study seeks to provide baseline data that will facilitate the development of site-specific nutrient management guidelines for farmers in Sahatsakhan District, ensuring sustainable land use in this geographically distinct region.

Materials and Method

The research methodology employs precision agriculture technology for in-situ soil fertility assessment. The study area is centrally located at Latitude 16.7151°N and Longitude 103.5137°E. This specific location was strategically selected to encompass two distinct geomorphological zones: the Mesa plateau and the Foothill slopes. The operational procedure is structured into three phases as follows

1.Investigation of Soil Fertility in Mesa side The first phase focused on collecting data from the Mesa side (flat-topped hill). A survey was conducted on the flat plateau surface surrounding the central coordinates. Soil fertility was measured directly in the field using a Soil Multi-parameter Sensor, allowing for real-time analysis without the need for laboratory extraction. Measurements were taken at a soil depth of 0–30 cm. Key parameters recorded included Soil Temperature, Moisture Content, pH level, and Macronutrients (Nitrogen-N, Phosphorus-P, and Potassium-K).

2.Investigation of Soil Fertility in Foothill side The second phase involved assessing the Foothill side, specifically the depositional zones at the base of the Mesa structure. Measurements were taken in the lower slope areas using the same Soil Multi-parameter Sensor to maintain calibration consistency and minimize instrumental error. Soil properties (Temperature, Moisture, pH, N, P, K) were recorded at the same depth (0–30 cm) to characterize the fertility status of the sediment-receiving areas.

3.Comparative Analysis of Soil Fertility The final phase involved the statistical processing and comparison of the data obtained from the two distinct topographies. The raw data from the multi-parameter sensor were compiled to calculate the mean values for each parameter. A comparative analysis was then performed to evaluate the differences in chemical fertility (N-P-K, pH) and physical conditions between the Mesa (erosion source) and the Foothill (deposition zone). The results were interpreted to determine the spatial variability of soil fertility, leading to site-specific recommendations for agricultural management in the Phu Sing hill area.

Results

1. Results of Soil Fertility Analysis in Mesa side

Table 1 : Descriptive Soil Fertility result about temperature , soil nutrients (N,P,K) , pH and moisture value of 5 samples from Mesa side

sample	temperature (℃)	Soil nutrients			pH	Moisture value %
		N	P	K		
1	29.7	15	81	74	7.3	27.3
2	32	13	78	70	7.2	26.7
3	30.9	10	70	63	7.9	23.8
4	28.9	16	83	75	7.8	25.5
5	24.4	10	71	63	7.5	25.5
mean	29.18	12.8	76.6	69	7.54	25.76

The results of soil Fertility analysis on the Mesa side indicate that soil temperature ranged from approximately 24.40 to 32.00 ℃, which is suitable for biological activity in the soil. However, the concentrations of major nutrients, including nitrogen (N), phosphorus (P), and potassium (K), were generally low to moderate. Nitrogen levels were particularly low at several sampling points, suggesting limited soil fertility. This condition may be attributed to soil erosion and nutrient leaching commonly occurring in elevated areas. The soil pH values ranged from 7.20 to 7.90, indicating slightly alkaline conditions, which may affect nutrient availability and uptake by plants. In addition, soil moisture content was relatively low, reflecting limited water-holding capacity of the soil on the Mesa side.

2. Results of Soil Fertility Analysis in Foothill side

Table 2 : Descriptive Soil Fertility result about temperature , soil nutrients (N,P,K) , pH and moisture value of 5 samples from Foothill side

sample	temperature (°C)	Soil nutrients			pH	Moisture value %
		N	P	K		
1	25.9	32	120	113	7.6	33.4
2	25.6	37	133	126	7.2	25.7
3	30.6	36	130	123	7.3	26.8
4	31.1	20	93	85	7.2	29.7
5	30	18	88	81	6.8	37.7
mean	28.64	28.6	112.8	105.6	7.22	30.66

Soil analysis on the Foothill side revealed significantly higher levels of major nutrients (N, P, and K) compared to the Mesa side. Phosphorus and potassium concentrations were consistently high across most sampling points, indicating nutrient accumulation in the foothill area. Soil temperature remained within a suitable range for plant growth, while soil pH values ranged from 6.80 to 7.60, close to neutral conditions, which favor nutrient availability for plants. Moreover, soil moisture content on the Foothill side was relatively higher, suggesting better water retention capacity and the accumulation of sediments transported from higher elevations. These factors contribute to greater soil fertility in the Foothill area.

3. Comparative Analysis of Soil Fertility between Mesa and Foothill sides

Table 3 : Compared Soil fertility mean analysis between Mesa side and Foothill side

Area	temperature (°C)	soil nutrients			pH	moisture value %
		N	P	K		
soil on mesa	29.18	12.8	76.6	69	7.54	25.76
soil on foothill	28.64	28.6	112.8	105.6	7.22	30.66

The comparative analysis of average soil fertility between the Mesa and Foothill sides demonstrates that the Foothill soil contains substantially higher levels of nitrogen, phosphorus, and potassium than the Mesa soil. This pattern reflects the downward movement and accumulation of nutrients due to erosion and runoff from higher terrain. Soil pH values in both areas were slightly alkaline to near neutral, with the Mesa side exhibiting slightly higher pH values. In contrast, soil moisture content was higher in the Foothill area, indicating greater water-holding capacity and suitability for agricultural activities. Overall, the results suggest that the Foothill side acts as a nutrient accumulation zone, whereas the Mesa side requires targeted soil management practices to improve fertility and reduce nutrient loss.

Conclusion

This study highlights distinct differences in soil fertility between the Mesa and Foothill sides in Phu Sing. The Foothill area functions as a "nutrient sink," accumulating significantly higher levels of Nitrogen, Phosphorus, and Potassium compared to the Mesa plateau, which experiences nutrient depletion due to erosion. While both sides are slightly alkaline, the Foothill soil is notably richer.Consequently, sustainable agriculture in this region requires site-specific management prioritizing nutrient enrichment for the Mesa and monitoring high Phosphorus levels in the Foothill zone.

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