Determination of Soil NPK Using Spectrophotometry and Flame Photometry

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Abstract

Doi Saket District, in Chiang Mai Province, is an important agricultural area in Northern Thailand, characterized by diverse crop cultivation and extensive farming activities. However, the region faces increasing challenges to agricultural sustainability due to soil degradation and inefficient nutrient management. This study aimed to evaluate the fertility status of agricultural soils in Doi Saket District by quantifying the concentrations of primary macronutrients: nitrogen (as nitrate, NO_3^-), phosphorus (P), and potassium (K). Soil samples were systematically collected from representative agricultural sites and analyzed using spectroscopic techniques. Nitrate and phosphorus concentrations were determined via UV–Visible spectrophotometry using colorimetric methods—specifically the cadmium reduction method for nitrate and the molybdenum blue method for phosphorus. Potassium levels were measured using flame photometry based on atomic emission principles. Standard calibration curves were constructed to ensure analytical accuracy and reliability. The results revealed spatial variation in soil nutrient distribution across the district. Certain areas exhibited nitrate deficiency, while phosphorus accumulation was observed in specific locations. Potassium levels were generally within ranges suitable for crop production. These findings provide a scientific baseline for precision fertilizer management, supporting improved crop yields and minimizing environmental impacts associated with excessive fertilizer application.

Objective

To determine the concentrations of the primary macronutrients nitrogen (N), phosphorus (P), and potassium (K) in agricultural soils from Doi Saket District, Chiang Mai, using UV–Visible spectrophotometry and flame photometry in order to evaluate soil fertility and support appropriate fertilizer management.

Introduction

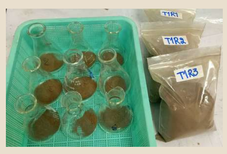
Soil fertility directly affects crop productivity and sustainability. Nitrogen (N), phosphorus (P), and potassium (K) are essential macronutrients required for plant growth. Therefore, accurate determination of soil NPK levels is important for evaluating soil fertility and supporting proper fertilizer management in agricultural areas such as Doi Saket District, Chiang Mai.



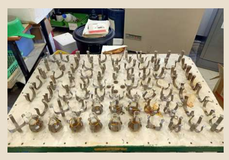


Methods

Extraction



5 g of soil was mixed with 20 mL of Mehlich I .



Shake the solution for 5 minutes.



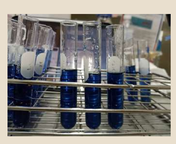
Filtered using Whatman No. 5 filter paper.

Analytical Method

- **Determination of Nitrate**



Develop the color of the solution by adding 0.020 g of mixed powder and 0.5 mL of Reagent A.

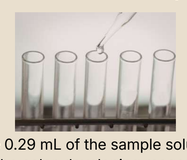


Allow to stand for 5 minutes.



Measure using UV–Vis spectroscopy at a wavelength of 530 nm.

- **Determination of Phosphorus**



Pipette 0.29 mL of the sample solution, then add 4.71 mL of the color-developing reagent.



Allow to stand for 30 minutes.



Measure using UV–Vis spectroscopy at a wavelength of 882 nm.

- **Determination of potassium**



Extracted soil solution



Measure using Flame photometry

Result and Discussion

1.Linearity and Calibration Curves

Table 1. Linear regression equations and coefficient of determination (R^2) of the calibration curves for N, P, and K.

Parameter	Equation	R^2
N	y = 0.0424x + 0.0964	0.9922
P	y = 0.8952x + 0.0721	0.9962
K	y = 0.9945x + 0.2131	0.9998

2.Soil N,P,K Concentrations

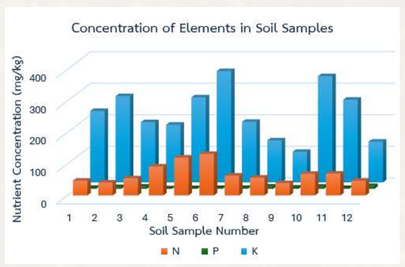


Figure 1. Concentrations of N, P, and K in soil samples (mg/kg).

3.Discussion of Soil Fertility Status

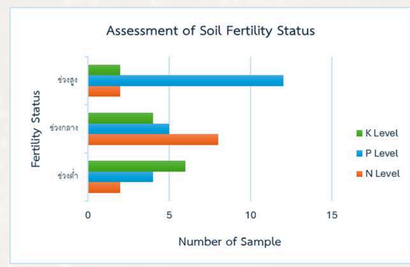


Figure 2. Comparison of soil fertility levels based on NPK concentrations.

4.Precision of the Analytical Method

Table 2. Precision of the analytical methods expressed as %RSD for N, P, and K.

Parameter	Mean %RSD	Max %RSD	Min %RSD
N	2.02	7.15	0.23
P	0.65	2.17	0.16
K	1.1	3.3	0.1

Conclusion

- Soil nitrogen (N), phosphorus (P), and potassium (K) were successfully quantified using UV–Visible spectrophotometry and flame photometry, demonstrating satisfactory linearity and precision.
- High correlation coefficients and low %RSD values confirm the reliability and analytical accuracy of the methods applied.
- The results indicate relatively high potassium levels, low phosphorus concentrations,and sufficient nitrogen content compared with standard reference values.
- These findings support environmentally appropriate soil fertility assessment and provide a scientific basis for sustainable and site-specific nutrient management.

References

1. Chapman, H.D. (1965). Cation Exchange Capacity. In Methods of Soil Analysis, Part 2 (pp. 891–913). American Society of Agronomy, Madison, Wisconsin.
2. Land Development Department. (2010). Chemical Soil Analysis Manual. Document No. OSD-03 (Revised Edition). Bangkok, Thailand.

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