Jurnal Tanah dan Air (*Soil and Water Journal*)
ISSN: 1411-5719(p): 2655-500X (e), Volume 22 Nomor 1 (June 2025): 38 – 50 (http://jurnal.upnyk.ac.id/index.php/jta/index)

Assessment of Soil Chemical Fertility Status in Wukirsari Sub-District, Cangkringan, Sleman, Special Region of Yogyakarta

Kajian Status Kesuburan Kimia Tanah di Kalurahan Wukirsari, Kapanewon Cangkringan, Kabupaten Sleman, Daerah Istimewa Yogyakarta

Ema Fransisca[1], and Eko Amiadji Julianto[2*]
[1] Department of Soil Science, Faculty of Agriculture, UPN "Veteran" Yogyakarta
*) Corresponding author: ekoadji@upnyk.ac.id

ABSTRACT

Agricultural productivity is influenced by soil fertility, which depends on the nutrient content of the soil as well as the land use and management practices applied. The objective of this study is to determine the chemical properties of the soil, assess its chemical fertility status, and identify any limiting factors. The research was conducted from December 2024 to February 2025, utilizing survey methods and laboratory analysis according to the criteria of the Soil Research Center (1995). Representative sample points were determined by a purposive method on the overlay results of thematic maps (Land Use Maps, Slope Maps, Elevation Maps) and resulted in 12 Land Units. The analysis results showed that the Cation Exchange Capacity (CEC) values range from 2.2 – 7.55 cmol (+)/kg classified as very low to low, Base Saturation (BS) ranges from 56.24 – 99.99% categorized as high to very high, P_2O_5 was 59.66 – 88.37 mg/100g classified as high to very high, K_2O was 2.09 - 15,51 mg/100g categorized as very low to low, C-organic was 0.46 – 2.38% classified as low to moderate, and pH H_2O was 4.83 – 7.7 indicating acidic to slightly alkaline conditions therefore the status of soil chemical fertility obtained 2 status, very low covering an area of 373.19 ha (39.42%) and low covering 600,09 ha (60,58%). The low fertility status is mainly influenced by the low Cation Exchange Capacity, content of K_2O, and Organic Carbon.

Keywords: Cation Exchange Capacity (CEC), Base Saturation, P_2O_5 Availability, K_2O Availability, C-Organic, Wukirsari Sub-district.

ABSTRAK

Produktivitas pertanian dipengaruhi oleh tingkat kesuburan tanah, yang bergantung pada kandungan unsur hara tanah serta penggunaan dan pengelolaan lahan yang diterapkan. Tujuan penelitian ini adalah untuk mengidentifikasi karakteristik sifat kimia tanah, menentukan status kesuburan kimia tanah, dan menganalisis faktor pembatas. Penelitian dilakukan pada bulan Desember 2024 hingga Februari 2025 menggunakan metode survei dan analisis laboratorium sesuai kriteria Pusat Penelitian Tanah (1995). Titik sampel pewakil ditentukan secara *purposive* pada hasil *overlay* peta tematik (Peta Penggunaan Lahan, Peta Kelerengan, Peta Ketinggian Tempat) dan menghasilkan 12 Satuan Lahan. Hasil analisis menunjukkan nilai Kapasitas Pertukaran Kation 2,2 - 7,55 cmol(+)/kg dengan harkat sangat rendah sampai rendah, Kejenuhan Basa 56,24 - 99,99% dengan harkat tinggi sampai sangat tinggi, kandungan P_2O_5 59,66 - 88,37 mg/100g dengan harkat tinggi sampai sangat tinggi, kandungan K_2O 2,09 - 15,51 mg/100g dengan harkat sangat rendah sampai rendah, C-organik 0,46 – 2,38% dengan harkat rendah sampai sedang, dan pH H_2O 4,83 – 7,7 tergolong masam sampai agak alkalis sehingga diperoleh 2 status kesuburan kimia tanah, yaitu sangat rendah dengan luas 373,19 ha (39,42%) dan rendah dengan luas 600,09 ha (60,58%). Faktor pembatas yang menjadi penyebab rendahnya kesuburan tanah adalah Kapasitas Pertukaran Kation, kandungan K_2O, dan C-organik.

Kata kunci : ***Kapasitas Penukar Kation (KPK), Kejenuhan Basa (KB), Ketersediaan P_2O_5, Ketersediaan K_2O, C- Organik, Wukirsari***

INTRODUCTION

Wukirsari sub-district is part of Kapanewon Cangkringan in Sleman Regency. Most of the land is used for farming, mainly growing paddy rice, along with corn, chili, and vegetables. The variety of crops shows the different ways land is used in the area. agricultural activities take place on land with different slope gradients, ranging from relatively flat areas to steep hillsides. These variations in topography and land use can greatly influence soil nutrient dynamics and fertility, as slope affects erosion risk, surface runoff, and the distribution of organic and mineral content in the soil (Merga et al., 2023).

The agricultural sector plays a key role in regional development in Indonesia. As the main staple food source for Indonesians, rice plays a strategic role in supporting national food security. According to Dinas Pertanian, Pangan dan Perikanan Kabupaten Sleman (2024), rice production in Sleman Regency decreased from 252,718 tonnes in 2023 to 207,000 tonnes in 2024. The research site, located in Kapanewon Cangkringan, also experienced a decline in production, falling from 13,398 tons of milled dry grain (MDG) to 12,500 tons.

This decline in production is inextricably linked to the state of the land resources that support agricultural systems, including land use diversity and topographic conditions such as slope and altitude. In the Wukirsari sub-district, where the soil type is regosol and the topography varies, the availability of nutrients and the soil's capacity to support plant growth are strongly influenced by its physical and chemical properties. Soil fertility status strongly influences the ability of soil to support plant growth and crop production (Hansen et al., 2023).

Soil fertility status is an important factor in determining a soil's ability to provide the nutrients necessary for plant growth. Therefore, efforts to maintain and improve soil fertility are crucial for increasing agricultural productivity and ensuring food security. Despite its agricultural importance and topographical diversity, Wukirsari Sub-district lacks comprehensive studies evaluating its soil chemical fertility. The present study aims to address this gap by assessing the chemical fertility status of soils in the area and identifying the key limiting factors that may affect crop productivity.

MATERIALS AND METHODS

The research was conducted from December 2024 to February 2025 in the Wukirsari subdistrict of the Kapanewon Cangkringan region of Sleman, in the Special

Region of Yogyakarta. Soil analysis was conducted at the Faculty of Agriculture Laboratory at Universitas Pembangunan Nasional Veteran in Yogyakarta. The tools and materials used in this research are listed below:

1. Field survey equipment in the form of soil drills, Avenza maps, clinometers, hoes, picks, stationery, labels, plastic bags, meters/rulers, cameras, and laptops with ArcGIS 10.8 and Microsoft Office 2019 software.
2. Materials used in the form of Administration Maps, Land Use Maps, Slope Maps, and Elevation Maps.

This study used survey and laboratory analysis methods. The survey method involved direct analysis in the field to identify topographic conditions, land use types, and land utilization and management practices. Data were collected through interviews and documentation. Laboratory analysis was conducted to determine soil chemical properties, including Cation Exchange Capacity (CEC) and Base Saturation (BS) using 1 N ammonium acetate (NH_4OAc) extraction at pH 7 methods; available P_2O_5 and K_2O using spectrophotometry; organic carbon (C-organic) using the Walkley and Black method; and soil pH using the H_2O method.

The research sample points were determined using a purposive sampling method based on the Land Unit Map (Figure 1). Based on the Land Unit Map, the sample coordinate points were determined by considering the type of land use, slope, and altitude. The sample coordinate points that have been determined are attached in Table 1.

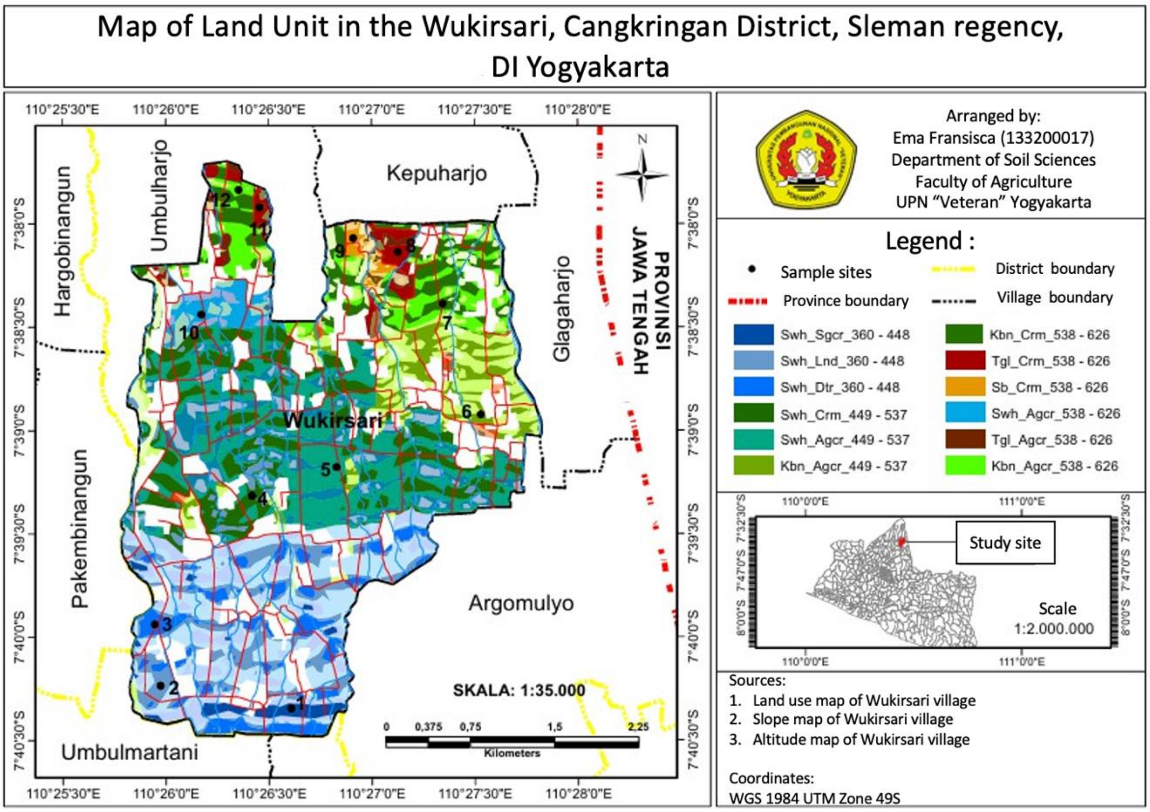


Figure 1. Map of Land Unit and Sampling Points

Table 1. Sampling Coordinates

Site samples	Land Unit	Coordinates	
		X	Y
1	Swh_Sgcr_360 – 448	438252	9152316
2	Swh_Lnd_360 – 448	438394	9152653
3	Swh_Dtr_360 – 448	438453	9152562
4	Swh_Crm_449 – 537	438753	9154292
5	Swh_Agcr_449 – 537	438844	9154278
6	Kbn_Agcr_449 – 537	439415	9154589
7	Kbn_Crm_538 – 626	439091	9155901
8	Tgl_Crm_538 – 626	438829	9155991
9	Sb_Crm_538 – 626	439310	9155922
10	Swh_Agcr_538 – 626	438009	9155411
11	Tgl_Agcr_538 – 626	438637	9156040
12	Kbn_Agcr_538 – 626	439046	9155864

Source: Map of Research Site Land Units

Description:
Land Unit Slope
Swh_Sgcr = Very steep rice fields Flat = 0 – 8%
Swh_Lnd = Sloping rice fields Sloping = 8 - 15%
Swh_Dtr = Flat rice fields Rare Steep = 15 –
25% Swh_Crm= Steep rice fields Steep = 25 –
45% Swh_Agcr= Somewhat steep rice fields Very Steep = > 45%
Kbn_Agcr = Lantation_ Little Steep
Kbn_Crm = Lantation_Steep
Tgl_Crm = Rainfed Land_Steep
Tgl_Agcr = Rainfed Land_Slightly Steep
Sb_Crm = Shrubs_Steep

The Land Unit Map is obtained from the overlay of Thematic Maps, namely the Land Use Map (Figure 2), Slope Map (Figure 3), and Elevation Map (Figure 4).

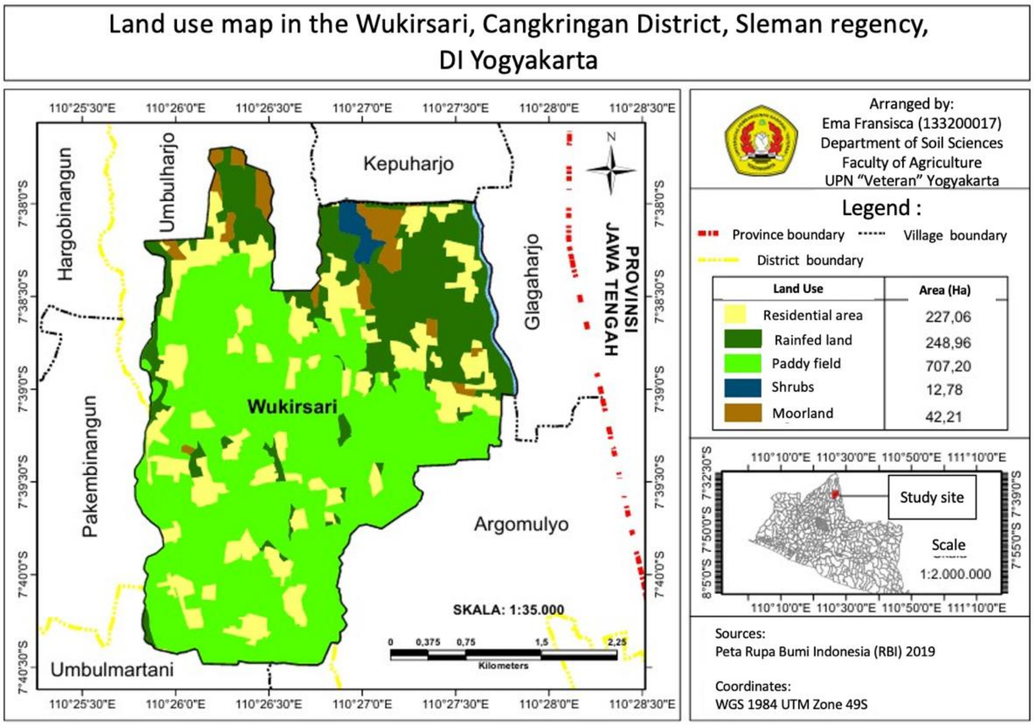


Figure 2. Land Use Map of Wukirsari Sub-district

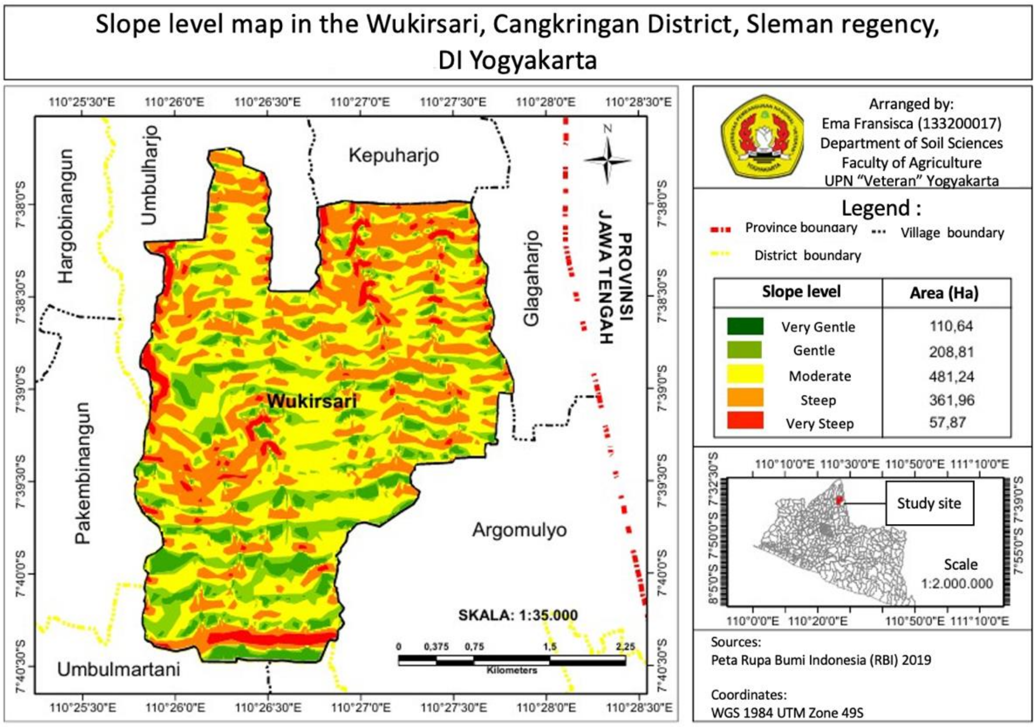


Figure 3. Slope Map of Wukirsari Sub-district

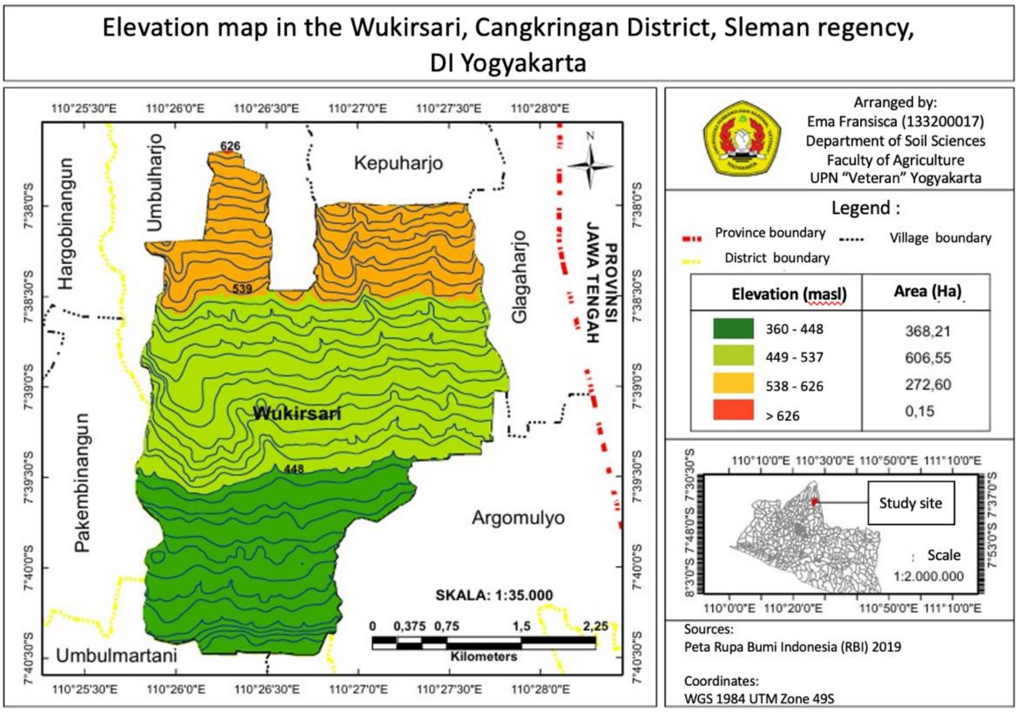


Figure 4. Elevation map of Wukirsari sub-district

Soil sampling was carried out to determine the criteria for soil fertility levels at predetermined representative sampling points. Sampling begins with cleaning the soil surface to reduce the accumulation of fertiliser and leaf litter, after which taking soil using a soil drill with a depth limit of 30 cm.

Determination of soil fertility status is based on the technical guidelines for soil fertility evaluation of the Soil Research Centre, Bogor (PPT, 1995) presented in Table 2, then a map of the soil fertility status of Wukirsari sub-district is made based on data on soil fertility parameters that have been measured and soil fertility status that has been obtained.

Table 2: Combination of soil chemical properties and soil fertility status

No	CEC	SB	P_2O_5, K_2O, C-organik	Soil Fertility Status
1.	T	T	≥2 T without R	High
2.	T	T	≥2 T with R	Medium
3.	T	T	≥2 S without R	High
4.	T	T	≥2 S with R	Medium
5.	T	T	T > S > R	Medium
6.	T	T	≥2 R with T	Medium
7.	T	T	≥2 R with S	Low
8.	T	S	≥2 T without R	High
9.	T	S	≥2 T with R	Medium
10.	T	S	≥2 S	Medium
11.	T	S	other combinations	Low
12.	T	R	≥2 T without R	Medium
13.	T	R	≥2 T with R	Low
14.	T	R	other combinations	Low
15.	S	T	≥2 T without R	Medium
16.	S	T	≥2 S without R	Medium
17.	S	T	other combinations	Low
18.	S	S	≥2 T without R	Medium
19.	S	S	≥2 S without R	Medium
20.	S	S	other combinations	Low
21.	S	R	3 T	Medium
22.	S	R	other combinations	Low
23.	R	T	≥2 T without R	Medium
24.	R	T	≥2 T with R	Low
25.	R	T	≥2 S without R	Medium
26.	R	T	other combinations	Low
27.	R	S	≥2 T without R	Medium
28.	R	S	other combinations	Low
29.	R	R	all combinations	Low
30.	SR	T, S, R	all combinations	Very Low

RESULTS AND DISCUSSION

A. Identification of Soil Chemical Characteristics

The results of the analysis of soil chemical properties are presented in Table 3.

Table 3. The Soil Chemical Properties over study area

Site Samples	Land Unit	Soil Chemical Properties: CEC (cmol(+)/kg)	BS (%)	P_2O_5 (mg/100mg)	K_2O (mg/100mg)	C-organik (%)	pH H_2O
Site 1	Paddy Field >45% 360 – 448	7.55	99.99	77.74	6.47	1.27	7.26
Site 2	Paddy Field 8-15% 360 – 448	5.11	99.96	77.72	8.83	0.82	7.53
Site 3	Paddy Field 0-8% 360 – 448	5.36	99.98	86.76	6.22	1.34	7.47
Site 4	Paddy Field 25-45% 449 – 537	5.62	99.98	88.37	7.26	0.74	7.4
Site 5	Paddy Field 15-25% 449 – 537	4.7	99.98	85.18	9.27	0.79	7.41
Site 6	Plantation 15-25% 449 – 537	5.36	99.98	70.74	15.51	1.47	7.3
Site 7	Plantation 25-45% 538 – 626	2.2	99.95	74.77	5.12	0.46	7.7
Site 8	Rainfed land 25-45% 538 – 626	6.9	99.99	59.66	3.22	2.38	7.5
Site 9	Shrub 25-45% 538 – 626	4.37	99.98	70.71	2.13	1.8	7.49
Site10	Paddy field 15-25% 538 – 626	3.43	56.24	61.49	2.09	0.53	4.83
Site 11	Rainfed land 15-25% 538 – 626	6.12	87.75	78.54	4.12	1.85	6.41
Site 12	Plantation 15-25% 538 – 626	5.68	94.72	67.75	3.59	1.97	6.8

1. **Cation Exchange Capacity (CEC)**

Cation exchange capacity reflects the ability of soil to hold and exchange cations (positively charged ions). The results of the analysis of soil CEC values from each sample point are classified as very low to low. The highest CEC value was found at point 1 with rice field land use (15-25% slope and 360 - 448 altitude) with a value of 7.55 cmol (+)/kg, while the lowest value was found at point 7 with garden land use (25-45% and 538 - 626 altitude) with a value of 2.2 cmol (+)/kg.

The low value of CEC is due to the lack of organic matter input on each agricultural land, which results in a lack of nutrient supply in the soil. Soils with low organic matter content generally have low cation exchange capacity, due to the small amount of negative charge available to bind cations (Hairiah et al., 2000). In addition, the diverse topography, from flat to steep slopes and highlands, makes the study site susceptible to erosion. As a result, the topsoil, which is usually rich in organic matter and clay minerals that are the main contributors to the CEC, will disappear because it is carried away by surface flow during heavy rains.

2. **Base Saturation (BS)**

Base saturation is the percentage of cation exchange capacity occupied by base cations such as calcium, magnesium, potassium, and sodium. The results of the SB value analysis are classified as high to very high. The highest base saturation was found at point 1 with paddy field land use (slope 15-25% and altitude 360 - 448) and point 8 with moor land use (slope 25-45% and altitude 538 - 626), with a value of 99.99%. On the other hand, the lowest SB is found at point 10 with paddy field land use (15-25% and altitude 538-626), with a value of 56.24%.

The high level of base saturation at the research location is the result of long-term land management activities. One contributing factor is the repeated application of inorganic fertilizers such as Phonska or Urea, which are often applied together with alkaline ameliorants such as dolomite. This combination enriches the soil with base cations such as Ca^{2+}, Mg^{2+}, K^{+}, and Na^{2+}, thereby increasing soil base saturation (Suntoro, 2009).

3. **Phosphorus status**

Phosphorus (P) is one of the natural essential macronutrients in the form of organic or inorganic compounds. Both forms are insoluble forms of phosphorus, so their availability is very limited. The results of the analysis of the P_2O_5 HCl 25% value are classified as high to very high. The highest P2O5 content is found at point 4 with rice field land use (slope 25-45% and altitude 449 - 537) has a value of 88.37 mg/100mg, while the lowest is found at point 8 with moor land use (slope 25-45% and altitude 538 - 626) has a value of 59.66 mg/100mg.

The high P_2O_5 content, especially in paddy fields, is due to the additional P nutrients from inorganic fertilizers such as Phonska, Urea and TSP fertilizers. Phonska fertilizer contains phosphate (P_2O_5) by 15%, while TSP fertilizer contains P_2O_5 around 44 - 46% (Ramli, 2021). In addition, the intensive cultivation systems in paddy fields—characterized by frequent fertilization—contribute to the higher availability of phosphorus in the soil.

Regular application of phosphorus-based fertilizers, combined with irrigation, enhances phosphorus solubility and mobility, thereby increasing its availability to crops. In contrast, drylands such as moorlands and gardens typically receive minimal fertilization and lack a consistent water supply, which limits phosphorus input and reduces its mobility and retention in the soil. As a result, phosphorus accumulation tends to be lower in these areas. These differences in land use management practices play a critical role in shaping phosphorus dynamics and availability across the landscape.

4. Potassium status

Potassium is an essential macronutrient that plays an important role in plant metabolism, water regulation, and increasing resistance to environmental stresses such as drought and pest attacks. The results of the analysis of 25% HCl K_2O content are classified as very low to low. The highest K_2O content was found at point 6 with garden land use (slope 15 - 25% and altitude 449 - 537) with a value of 15.51 mg/100mg, while the lowest K_2O content was found at point 10 with rice field land use (slope 15 - 25% and altitude 538 - 626) with a value of 2.09 mg/100mg.

5. C-organic

C-organic is the fraction of carbon derived from organic matter, such as crop residues, litter, manure, and microorganisms that have undergone decomposition. The results of the analysis of C-organic content are classified as very low to medium. The highest C-organic content is found at point 8 with the use of moor land (slope 25-45% and altitude 538 - 626) has a value of 2.38%, while the lowest C-organic content is found at point 7 with garden land use (25-45% and altitude 538 - 626) has a value of 0.46%.

The low C-organic content is due to the lack of organic matter input. On moorland, cultivation activities are generally carried out seasonally with limited application of manure or crop residues. However, this organic matter input is still able to maintain C-organic. In contrast, on plantation land dominated by perennial crops, organic matter inputs are minimal due to limited organic fertilization.

6. Soil pH

Soil reaction is an indicator of the acidity or basicity of a soil that affects the availability of nutrients and the activity of microorganisms. The highest pH result is at point 7, with garden land use (slope 25-45% and altitude 538-626) has a value of 7.7, classified as slightly alkaline, while the lowest pH is at point 10 with rice field land use (slope 15-25% and altitude 538-626) classified as acidic.

The results show that the soil pH across all sampling points falls within a neutral range, approximately between 6.0 and 7.0. This condition was found at several sample points, especially in the rice field land use. This neutral soil reaction indicates that the soil is in an optimal condition for the growth of most plants, because nutrients are available in sufficient quantities and can be absorbed by plants effectively. In addition, the dominant use of inorganic fertilizers, especially Urea, can increase the accumulation of H^+ ions in the soil due to the nitrification process, thus reducing soil pH gradually (Brady and Weil, 2010).

B. Soil Chemical Fertility Status

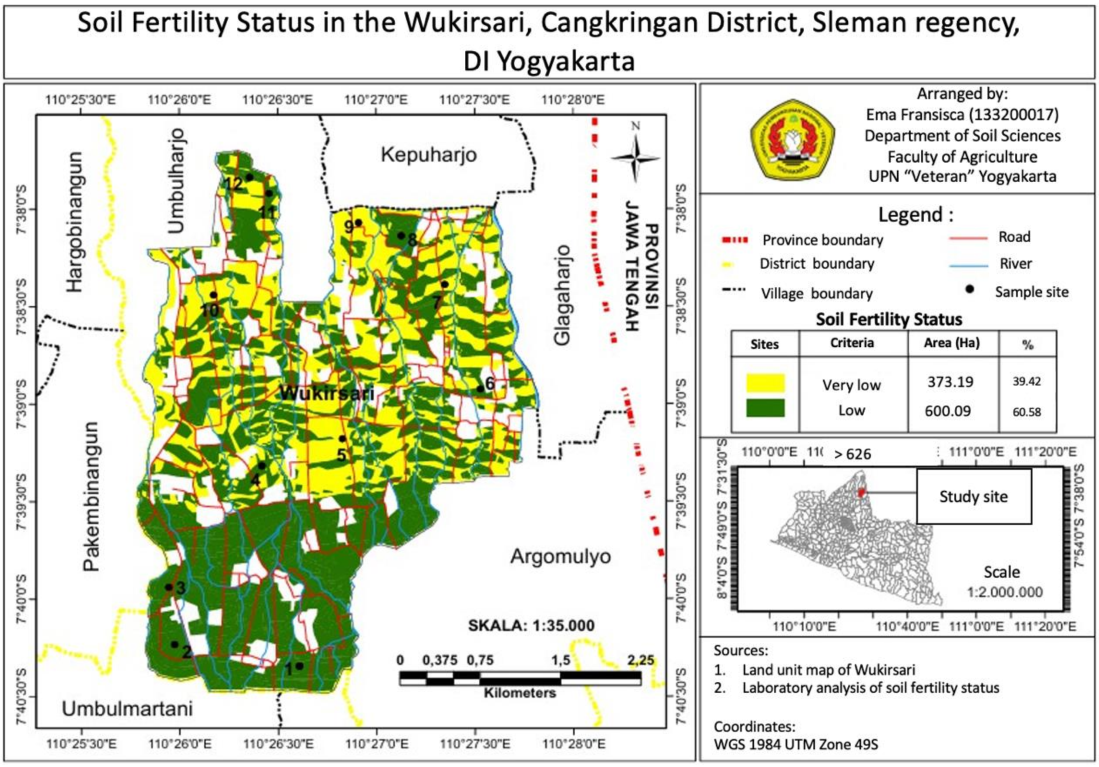
Based on the criteria of soil fertility status, two soil fertility statuses were obtained, namely very low fertility and low fertility. Very low fertility status is found at the location of sample points 5, 7, 9, and 10, and other sample points have low fertility status. Low fertility status is influenced by the presence of limiting factors, namely low CEC, K_2O, and C-organic content. This indicates the low ability of the soil to store and provide nutrients. Soil chemical fertility status is presented in Table 4.

Table 4. Soil Chemical Fertility Status of Wukirsari Village

Site Samples	Vegetation	CEC (cmol(+)/kg)	BS (%)	P_2O_5 (mg/100 mg)	K_2O (mg/100 mg)	C-organic (%)	Fertility status
Site 1	Paddy	L	VH	VH	VL	L	L
Site 2	Paddy	L	VH	VH	VL	VL	L
Site 3	Paddy	L	VH	VH	VL	L	L
Site 4	Paddy	L	VH	VH	VL	VL	L
Site 5	Paddy	VL	VH	VH	VL	VL	VL
Site 6	Cassava	L	VH	VH	L	L	L
Site 7	*Albizia chinensis*	VL	VH	VH	VL	VL	VL
Site 8	Mahogany	L	VH	VH	VL	M	L
Site 9	Grass	VL	VH	H	VL	L	VL
Site 10	Paddy	VL	H	VH	VL	VL	VL
Site 11	Chilli	L	VH	VH	VL	L	L
Site 12	Bamboo	L	VH	VH	VL	L	L

The low CEC value reinforces the characteristic of regosol soils that are poor in 2:1 type clay minerals, such as montmorillonite, that play a role in increasing cation exchange capacity. In addition, the low K_2O is not only in line with the characteristics of regosol soils that tend to be nutrient poor, but also reflects the high level of potassium loss due to leaching and the lack of potassium inputs from farmers. Steep slopes increase the risk of erosion, especially during the rainy season, leading to the loss of nutrient-rich topsoil and organic matter.

The research area is located in the highlands makes the air temperature relatively lower. Low temperatures can slow down the decomposition of organic matter by microorganisms, resulting in low soil C-organic content (Suryani et al., 2010). Low C-organic content was found in most of the sample points, reflecting the low input of organic matter from crop residues or organic fertilizers. This field finding is reinforced by direct observation of land conditions that show minimal use of organic matter by local farmers, as well as cultivation practices that still rely on limited inorganic fertilizer inputs. The distribution of soil fertility status is presented in Figure 2.



Picture 5 Distribution Map of Soil Chemical Fertility Status of Wukirsari Sub-district

CONCLUSION

The results of laboratory analyses obtained, CEC values are rated very low to low. Base Saturation and P_2O_5 are rated high to very high. K_2O content is very low to low. C-organic is rated very low to medium and pH H_2O is classified as acidic to slightly alkaline. The soil chemical fertility status in Wukirsari sub-district, Kapanewon Cangkringan, Sleman Regency, Yogyakarta Special Region has 2 fertility statuses, namely Very Low Fertility Status with an area of 373.19 ha (39.42%) and Low Fertility Status with an area of 600.09 ha (60.58%) of the study area. The limiting factors that influence low soil fertility are the content of Cation Exchange Capacity, K_2O, and soil C-organic.

REFERENCES

Brady, N.C., and Weil, R.R. 2010. *Elementas of The Nature and Properties of Soil*. Pearson Education.

Dinas Pertanian, Pangan, dan Perikanan. 2024. Data Produksi Padi Kabupaten Sleman Tahun 2023-2024. Sleman: Dinas Pertanian, Pangan, dan Perikanan.

Hairiah, K., Hanafiah, K. A., dan Van Noordwijk, M. 2000. *Ilmu Tanah untuk Studi-studi Agroforestri*. Bogor: ICRAF.

Hakim, N., N. Yusuf, A. Lubis, G.N. Sutopo, M.D. Amin, B.H. Go, dan H.H. Bailley. 1986. *Dasar-dasar ilmu tanah.* Lampung: Universitas Lampung. 153 hlm.

Hansen, V., Meilvang, L. V., Magid, J., Thorup-Kristensen, K., & Jensen, L. S. 2023. Effect of soil fertility level on growth of cover crop mixtures and residual fertilizing value for spring barley. *European Journal of Agronomy*, 145, 126796.

Hardjowigeno, S. 2007. *Ilmu Tanah*. Jakarta: Akademika Pressindo

Merga, K., Gidago, G., & Laekemariam, F. 2023. Soil Fertility Status as Influenced by Slope Gradient and Land Use Types in Southern Ethiopia. Applied and Environmental Soil Science, 2023, 1–13.

PPT. 1995. *Petunjuk Teknis Evaluasi Kesuburan Tanah.* Laporan Teknis No.14.

Versi 1,0. 1. REP II Project, CSAR, Bogor.

Ramli, N. 2021. Pengaruh Aplikasi Triple Super Phosphate (TSP) dalam Meningkatkan Produksi Tanaman Kacang Panjang (*Vigna sinensis* L.). *Jurnal Penelitian Agrosamudra*, *8*(1), 18-33.

Sparks, D.L. 2003. *Environmental Soil Chemistry*. Academic Press.

Suntoro. 2009. *Pengaruh Bahan Organik terhadap Sifat Kimia Tanah dan Produksi Tanaman*. Pidato Pengukuhan Guru Besar. Universitas Sebelas Maret.

Suryani, E., Utomo, W. H., & Husnain. 2010. Pengaruh Penambahan Bahan Organik terhadap Sifat Kimia Tanah dan Hasil Tanaman Jagung. Jurnal Tanah dan Lingkungan, 12(1), 1-6