Vol. 14, No. 5 (2025): 1778 - 1784 http://dx.doi.org/10.23960/jtep-l.v14i5.1778-1784

JURNAL TEKNIK PERTANIAN LAMPUNG

ISSN 2302-559X (print) / 2549-0818 (online)
Journal homepage : https://jurnal.fp.unila.ac.id/index.php/JTP

Analysis of Soil Erodibility Value Using the Wischmeier-Smith Method

Marchelino Rendi Pradana[1], Purnomo Edi Sasongko[1,✉], Maroeto[1]

[1] Departement of Agrotechnology, University of Pembangunan Nasional "Veteran" Jawa Timur, Surabaya, INDONESIA.

Article History:

Received : 15 September 2024
Revised : 11 March 2025
Accepted : 29 March 2025

Keywords:

Conservation,
Erodibility,
Land Use,
Physical Properties,
Soil.

Corresponding Author:
✉20025010154@student.upnjatim.ac.id
(Purnomo Edi Sasongko)

ABSTRACT

Soil erodibility is an important factor in determining soil loss. The objective of this study was to evaluate the soil erodibility value based on the Wischmeier-Smith Method. The study was carried out in Jatiarjo Village, Prigen District, Pasuruan Regency, at four land use units (LUU), including Mounts (MO), Mixed Garden (MI), Monoculture Garden (MG), and Shrubs (SR). Wischmeier-Smith algorithm was used to determine the erodibility values and classification. Results showed that shrub was identified as the land use with the highest potential for erosion and erodibility value. The correlation between clay fraction and erodibility has a negative value wit r = -0.76, while other fractions had r value < 0.5. This implied that the clay fraction and soil erodibility have an inverse relationship, where each increase in the clay fraction value will be followed by a decrease in the erodibility value. One way to reduce soil erodibility is to increase plant diversity on the land. Apart from adding organic matter, a variety of plants also have roots that are able to bind soil aggregates and help absorb water into the soil, thereby reducing water flow on the surface. If conservation is not taken seriously, it can undoubtedly result in.

1. INTRODUCTION

Soil erodibility is a condition where soil is more susceptible to erosion than other soils when all factors are the same, and the difference in lines is caused by the characteristics of the soil (Sulistyaningrum *et al*., 2014). Changes in soil properties during its formation affect soil erodibility, which is related to its susceptibility to erosion. According to Wang *et al*. (2016), soil erodibility describes the extent to which the soil surface is susceptible to soil erosion. Physical properties of the soil, such as texture, aggregate stability, soil structure, permeability and organic matter content play a major role in determining sensitivity to erosion. According to Marchianti *et al.* (2017), these properties affect erosion. Meanwhile, according to Hanifa & Suwardi (2022), sloping land is more susceptible to erosion because the soil texture is rougher than flat land.

Low soil erodibility can cause serious erosion on land with steep slopes and high rainfall, while high erodibility on land with light rainfall and gentle slopes does not pose an erosion hazard. Therefore, the assessment of soil erodibility needs to consider other factors separately (Wischmeier & Smith, 1978). Meanwhile, according to Arsyad (2006), the soil erodibility index is calculated using a formula involving the outer surface of the grain, the percentage of dust and clay in the soil. The field measurement method for erodibility has disadvantages related to time and cost, and involves complex interactions of physical and chemical properties of the soil. According to Wischmeier & Smith (1978), parameters such as dust, fine sand, organic matter, permeability and soil structure are used to calculate erodibility. In addition, the soil erodibility value can also be calculated using a soil erodibility nomograph.

According to the Wischmeier & Smith method (1978), the soil erodibility index (K) value is based on the amount of soil lost in tons/ha/year, from a plot of land on a slope length of 72.6 feet, a slope of 9% of the land can be cultivated but left unplanted. The analysis of the soil erodibility index (K) in this method is based on the % sand content, % dust content, % organic matter, type and class of soil structure and level of soil permeability (Injiliana *et al*., 2021). These numbers are then processed with a soil erodibility nomograph to determine the value of the soil erodibility factor index. This study aims to examine the relationship between soil physical properties and soil erodibility values in each type of land use. The results of this study are expected to be information for local governments regarding soil sensitivity to erosion events in various land uses.

2. RESEARCH MATERIALS AND METHODS

Soil sampling was carried out on 4 types of land use, namely mixed gardens (LK), monoculture gardens (LP), dry fields (LT), and shrub or bush land (LS). In each land use, soil samples were taken using tools in the form of hoes and shovels for disturbed soil and ring samples for loose soil. The disturbed soil sampling was carried out at 2 depths, namely 0–20 and 20–40 cm by taking soil that had been hoed and then put into plastic and labeled.

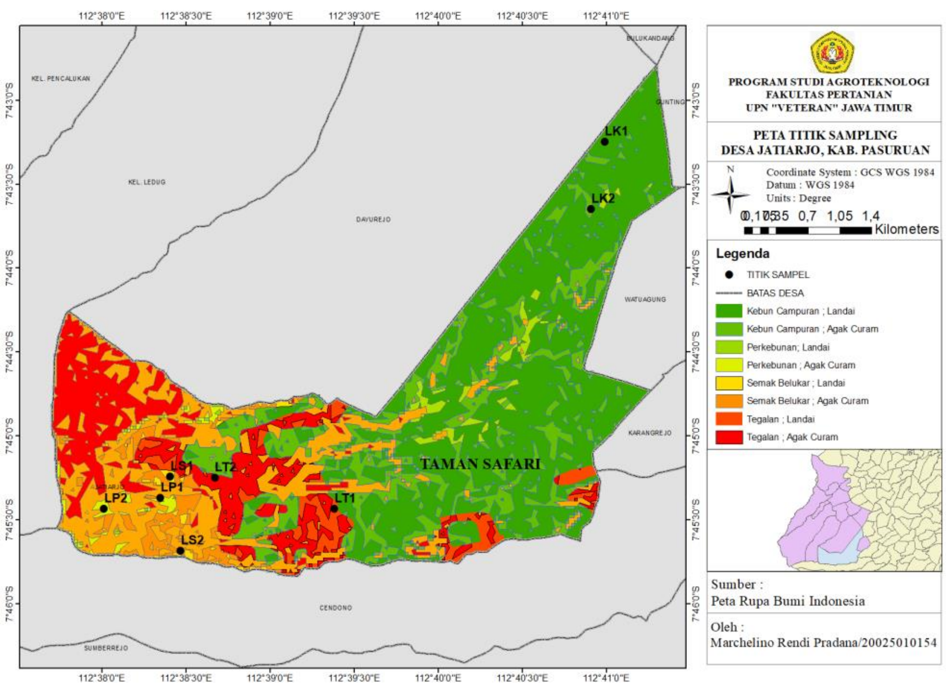

Figure 1. Research Location Map

Intact soil samples were taken using a ring sample placed on the ground. Then, a press was placed on the ring and hit until the ring entered the ground. This process was carried out twice at depths of 0–20 cm and 20–40 cm. After the sample ring was filled with soil, the ring was taken and flattened at both ends with a cutter. Furthermore, the sample ring was covered with a raw cotton and tied with rubber to prevent soil drying and to prevent it from being easily removed. Lifting the sample must be done carefully so that the sample is not damaged. The study involved the stages of primary data collection, secondary data collection, data processing, report preparation, and final assessment to determine the soil erodibility class.

Other tools needed are ArcGis software for making field maps, computer devices, GPS (Global Positioning System), land use maps, earth plates, sampling point maps, soil drills, sample rings, support tools, gauze, plastic, rubber, meters, cameras, ovens, scales, and spectrophotometers. While the materials are in the form of intact soil samples, disturbed soil, and intact aggregates at several points in the research location, reagent materials as additional materials in laboratory analysis. The erodibility was determined according to the Wischmeier-Smith (1978) as the following:

$$100\,K = 2.1\,M^{1.14}\,(10^{-4})\,(12 - a) + 3.25\,(b - 2) + 2.5\,(c - 3) \quad (1)$$

where K is soil erodibility, and M is calculated from (% silt + very fine sand) × (100 – % clay), a = % organic matter; b = soil structure rating based on the shape and size of the structure; c = soil permeability rating based on laboratory analysis. If the available texture data only include the fractions of sand, silt, and clay (%), then very fine sand is assumed to be one-third of the total sand percentage. After obtaining the structure, texture, organic material, and permeability values, these were entered into the K value calculation formula so that the level of soil sensitivity to erosion is known.

Table 1. Classification of *K* (soil erodibility) values

Class	1	2	3	4	5	6
***K* value**	0.00 – 0.10	0.11 – 0.21	0.22 – 0.32	0.33 – 0.44	0.45 – 0.55	0.56 – 0.64
Criteria	Very low	Low	Medium	Slightly high	High	Very high

Source: Wischmeier &Smith (1978)

2.1. Research Location

The research was conducted in Jatiarjo Village, Prigen District, Pasuruan Regency. Jatiarjo Village is an area located on the slopes of Mount Arjuno-Welirang and Ringgit with an altitude of 700–1500 meters above sea level with geographical coordinates (-7.74884, 112.63917). Pasuruan has soil types spread across the research area, namely Typic Hapludands, Andic Dystrudepts, and Typic Dystrudepts. Geologically, the Arjuno-Welirang complex is composed of volcanic rocks with a dusty clay soil texture.

3. RESULTS AND DISCUSSION

Based on the results of field observations, it is known that most of the soil structures in the Jatiarjo area are rounded lumps. The rounded lump structure is mostly found in soil resulting from processing so that it has large cohesion characteristics, is found in lower horizons, micro pores that contain more water, and lower macro pores so that air is not good in it. The size of soil particles affects the level of soil erodibility, where large particles are more resistant to the transport power of rainwater because of their size, while small particles are more resistant to the destructive power of rainwater because of their cohesiveness (Gupta *et al.,* 2024). There is a negative correlation between the clay fraction and erodibility, which means that the higher the clay fraction, the lower the soil erodibility, and vice versa, a decrease in the clay fraction will increase soil erodibility (Sholikah *et al.,* 2024).

The majority of soil structures in the Jatiarjo area are classified as rounded lumpy soil types. Rounded lumpy structures are often found in soil resulting from processing so that they have large cohesion characteristics, are found in lower horizons, micro pores that contain more water, and lower macro pores so that air is not good in them. The shape of the rounded soil structure such as the rounded lumpy structure produces soil with high porosity, so that water is easily absorbed into the soil and surface flow becomes small, so that erosion is also high (Rozi *et al*., 2022). The size of soil particles has an effect on the level of erodibility, where large particles are more resistant to transportation by rainwater because of their size, while small particles are more resistant to erosion due to the destructive power of rainwater due to their cohesive properties. The particles that are most susceptible to erosion by rainwater are fine sand and gravel particles. The stronger transport power in granular soil structures can reduce the level of soil erodibility (Ferdiansyah *et al*., 2023).

3.1. Soil Structure

Based on field observations, it is known that most of the soil structures in the Jatiarjo area are mostly included in value 4, namely the massive cubic type with a rounded lump structure. The rounded lump structure is found in large quantities in the soil resulting from processing so that it has large cohesion characteristics, is found in the lower horizon, micro pores that contain more water, and lower macro pores so that the air is not good in it (Maghfiroh *et al.,* 2022). The size of soil particles affects the level of erodibility, where large particles are more resistant to rainwater flow due to their size, while small particles are more resistant to destruction by rainwater due to their cohesive properties (Joniardi *et al.*, 2020). Soil particles such as dust and very fine sand are easily affected by the carrying capacity and destructive power of rainwater. Meanwhile, a granular soil structure with a higher carrying capacity can reduce the level of soil erodibility (Widiyanti *et al.*, 2022).

Table 2. Field observation results of soil structure

Land Use	Soil Structure	Grade
Mixed garden	Rounded lump	4
Upland dry fields	Rounded lump	4
Monoculture garden	Rounded lump	4
Shrubs	Rounded lump	4

Tabel 3. Soil erodibility values based on soil properties

Sample Code	Soil fraction (%)			Permeability (cm/hour)	Organic Matter (%)	Structure	Erodibility
	Sand	Silt	Clay				
LK1	21	28	51	0.96	6.29	Subangular blocky	0.09
LK2	21	25	54	0.91	5.87	Subangular blocky	0.09
LT1	46	35	19	6.58	3.75	Subangular blocky	0.19
LT2	48	36	16	4.87	3.39	Subangular blocky	0.25
LP1	53	34	13	2.56	3.82	Subangular blocky	0.16
LP2	67	23	10	3.61	3.42	Rounded lump	0.20
LS1	62	31	7	6.78	2.02	Subangular blocky	0.37
LS2	65	31	4	7.03	1.31	Subangular blocky	0.34

Note: LK = Mixed garden; LT = Upland dry field; LP = Monoculture garden; LS = Shrub land

3.2. Relationship between Soil Texture and Erodibility

Table 3 detailed soil properties in each land use along with the calculated soil erodibility values. Each soil fraction affects erodibility in a different way, so the resulting regression graphs also vary. The silt fraction, which is easily eroded or carried by water, does not have binding materials due to the lack of charge. In contrast, the clay fraction, although very fine, has a charge that makes it more difficult to decompose (Rahayu *et al.*, 2015).

Figure 2 shows the linear relationship between clay and sand fractions on soil erodibility resulting from this study. According to Sugiyono (2013), the correlation level based on the correlation coefficient (r) value can be grouped as follows: 0.00-0.199 (very low), 0.20-0.399 (low), 0.40-0.599 (moderate), 0.60-0.799 (strong), and 0.80-1.000 (very strong). Figure 2*a* shows that the clay fraction had a very strong correlation with *r* value of –0.82. The resulting R^2 value of 0.67 means that 67% of the decrease in soil erodibility was influenced by the clay fraction, while the rest was influenced by other factors. The sand fraction showed a strong correlation with *r* value of 0.79. The R^2 value of 0.63

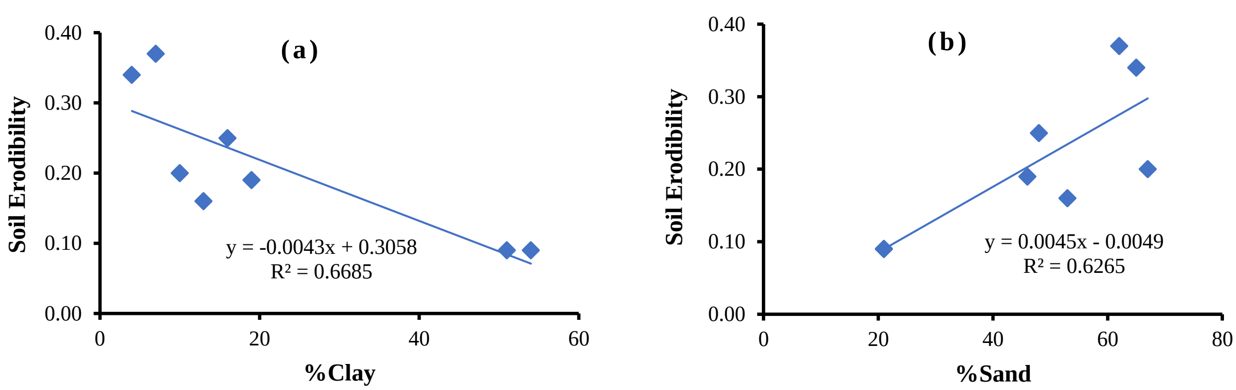

Figure 2. Soil erodibility as a function of: (a) clay fraction, and (b) sand fraction

(Figure 3) indicates that 63% of the increase in soil erodibility was influenced by the sand fraction, with other factors influencing the rest (Bakri *et al.,* 2022). In contrast, the silt fraction showed no correlation. According to

3.3. Relationship between Organic Material and Erodibility

The regression results show a correlation coefficient (*r*) of -0.92, indicating a very strong relationship between organic matter content and decreased soil erodibility. The regression graph shows that soil erodibility decreases with increasing organic matter. With an R^2 value of 0.844, this means that 84.4% of the decrease in soil erodibility is caused by organic matter, while the rest is influenced by other factors (Pebriani *et al.*, 2020). Vegetation and its root system help increase organic carbon content, improve soil structure, and increase permeability and water flow (Saha *et al*., 2022).

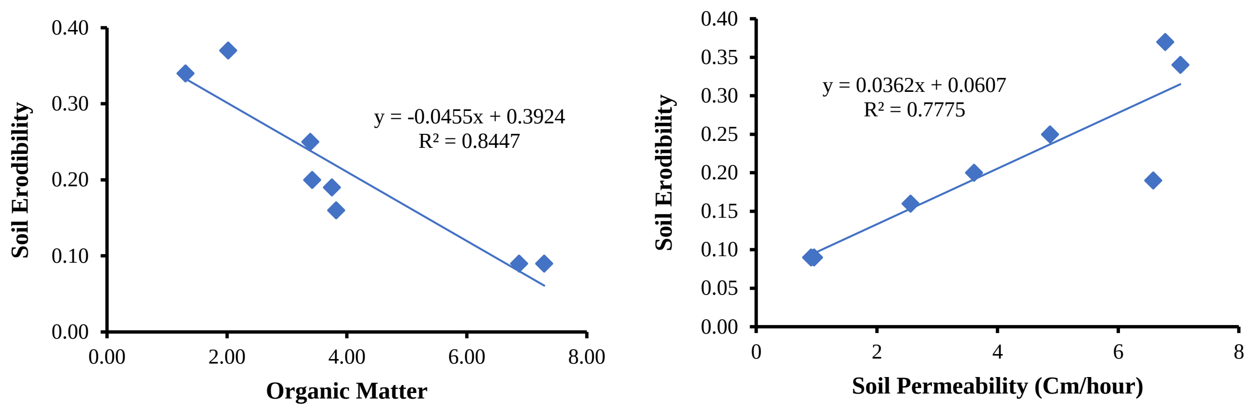

Figure 3. Soil erodibility as a function of soil properties: (a) organic matter, and (b) soil permeability

3.4. Relationship between Permeability and Soil Erodibility

The regression results show that the R^2 value is 0.77, which means that soil permeability affects soil erodibility by 77%, while the rest is influenced by other factors. This means a very strong correlation with *r* value of 0.88. The relationship between soil permeability and soil erodibility is positive, which means that an increase in soil permeability will be followed by an increase in soil erodibility. The higher the soil permeability, the lower the soil erodibility, this is because high soil permeability will reduce the rate of surface flow (Henrianto *et al*., 2019; Penhen *et al.,* 2022).

3.5. Relationship between Soil Erodibility and Land Use

The results of the analysis of variance show that land use has a significant effect on soil erodibility. The lowest soil erodibility value was obtained in mixed garden land use of 0.09 (very low), followed by monoculture gardens of 0.18 (rather low), then dry fields of 0.22 (moderate), and the highest erodibility was obtained in shrub land use of 0.36 (very high). The high erodibility value indicates that the soil on the land is very susceptible to erosion caused by rainwater. The high erodibility value in shrubland is influenced by vegetation factors which are dominated by shrubs and grasses and the lack of perennial plants in the area makes it susceptible to erosion. According to research by Muliatiningsih & Zulaeha (2018), in the condition of shrub land use, the level of resistance to the kinetic energy of raindrops is low. This is due to the vegetation factor which is not dense so that the related has a canopy that is not too wide, ultimately less able to hold raindrops on the ground surface. If no serious conservation efforts are made, this can cause losses. The high erodibility of soil in shrub land is caused by the lack of sufficient and diverse vegetation, as well as minimal litter. As a result, the organic matter content in the soil becomes low, which causes the soil to be less able to withstand erosion or rainwater attacks (Yunanda *et al.,* 2022). The lack of vegetation and low plant density cause rainwater to directly hit the ground surface, so that soil particles are more easily broken down into smaller ones.

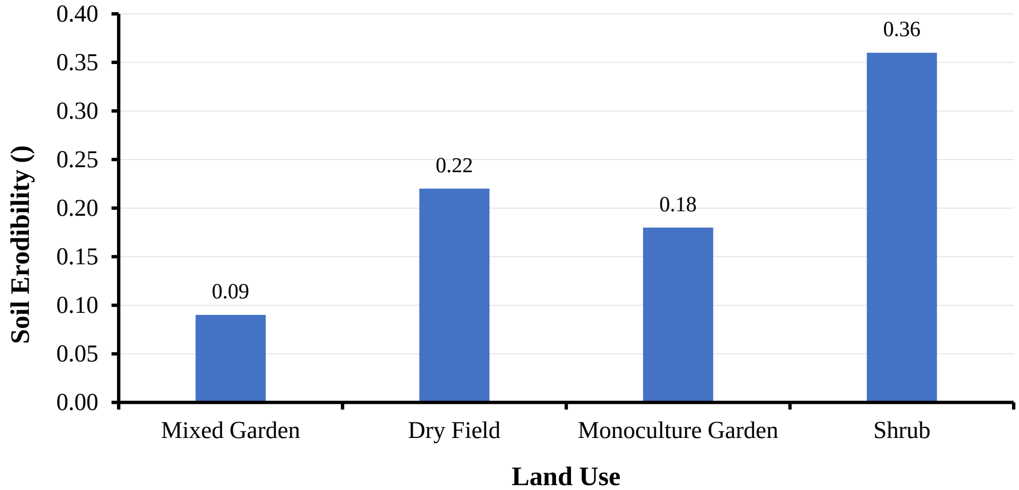

Figure 6. Regression of soil erodibility against land use

4. CONCLUSION

The highest erodibility value at the research site was found in the shrub land (LS2), with a value of 0.36, categorized as very high, indicating the greatest erosion potential. The use of shrubland requires conservation measures, such as constructing terraces or planting additional vegetation like calliandra or other perennial plants. Soil erodibility is influenced by four main factors: soil texture, organic matter content, soil structure, and soil permeability. Our study reveals that these factors have strong to very strong relation with soil erodibility.

ACKNOWLEDGEMENTS

The author would like to express sincere gratitude to the following parties: The Faculty of Agriculture, UPN "Veteran" Jawa Timur, for providing research support through access to the Soil Science Laboratory, and Balai Penerapan Standar Instrumen Pertanian (BSIP) Jawa Timur, for its support as a research partner.

REFERENCES

Arsyad, S. (2006). *Konservasi Tanah dan Air*. IPB Press, Bogor : 396 p.

Bakri, A., Pagiu, S., & Rahman, A. (2022). Analisis sifat fisika tanah pada beberapa penggunaan lahan di Desa Maku Kecamatan Dolo Kabupaten Sigi. *Agrotekbis: Jurnal Ilmu Pertanian*, ***10***(1), 1–8.

Ferdiansyah, W.Y., Harahap, F.S., Walida, H., & Septiyani, I.A.P. (2023). Soil erodibility prediction on oil palm land in Ujung Bandar Village, South Rantau District, Labuhanbatu Regency. *Biofarm : Jurnal Ilmiah Pertanian*, ***19***(2), 369. https://doi.org/10.31941/biofarm.v19i2.3414

Gupta, S., Borrelli, P., Panagos, P., & Alewell, C. (2024). An advanced global soil erodibility (K) assessment including the effects of saturated hydraulic conductivity. *Science of The Total Environment*, ***908***, 168249. https://doi.org/10.1016/j.scitotenv.2023.168249

Hanifa, H., & Suwardi. (2022). Nilai erodibilitas tanah pada berbagai penggunaan lahan dan tingkat kemiringan lahan di Sub Daerah Aliran Sungai Tulis, Banjarnegara, Jawa Tengah. *BIOFARM: Jurnal Ilmiah Pertanian*, ***18***(2), 160–165. https://jurnal.unikal.ac.id/index.php/biofarm/article/download/2449/1400

Henrianto, A., Okalia, D., & Mashadi, M. (2019). Uji beberapa sifat fisika tanah bekas tambang emas tanpa izin (PETI) di tiga kecamatan di daratan sepanjang Sungai Kuantan. *Jurnal Agronomi Tanaman Tropika (JUATIKA)*, ***1***(1), 19–31.

Injiliana, L., Widiastuti, T., & Riyono, J.N. (2021). Erodibilitas tanah (K) pada berbagai tutupan lahan di Desa Baru Kecamatan Silat Hilir Kabupaten Kapuas Hulu. *Jurnal Hutan Lestari*, ***8***(4), 773. https://doi.org/10.26418/jhl.v8i4.44323

Joniardi, J., Trides, T., & Magdalena, H. (2020). Studi tingkat erodibilitas tanah pada rencana pit Cincong Seam 50 PT. Lanna Harita Indonesia Sub CV. Rizky Maha Karya Utama, Kota Samarinda, Provinsi Kalimantan Timur. *Jurnal Teknologi Mineral FT UNMUL*, ***8***(2), 6–12.

Maghfiroh, C.N., Hartanti, D.A.S., Puspaningrum, Y., Zuhria, S.A., Khiftiyah, A.M., & Chumaidi, M. (2022). Identifikasi karakteristik tanah pertanian di Desa Banjarsari Kecamatan Bandar Kedungmulyo Kabupaten Jombang. *Exact Papers in Compilation (EPiC)*, ***4***(2), 551–556. https://doi.org/10.32764/epic.v4i2.767

Marchianti, A.C.N., Sakinah, E.N., & Diniyah, N. (2017). Efektifitas penyuluhan gizi pada kelompok 1000 HPK dalam meningkatkan pengetahuan dan sikap kesadaran gizi. *Journal of Agromedicine and Medical Sciences*, ***3***(3), 12-18. https://doi.org/10.19184/ams.v3i3.5331

Muliatiningsih, M., & Zulaeha, Z. (2018). kajian indeks erodibilitas tanah pada beberapa sistem pola tanam. *Jurnal Agrotek UMMat*, ***5***(1), 69. https://doi.org/10.31764/agrotek.v5i1.272

Pebriani, D.A., Padusung, & Arifin, Z. (2020). Hubungan berbagai kelas kemiringan lereng terhadap sifat kimia tanah di Desa Buwun Mas Kecamatan Sekotong Kabupaten Lombok Barat. *Journal of Soil Quality and Management JPPIPA*, ***7***(1), 1–8.

Penhen, N., Hartati, T.M., & Ladjinga, E. (2022). Penentuan laju infiltrasi dan permeabilitas tanah pada beberapa penggunaan lahan di Kelurahan Jambula. *Prosiding Seminar Nasional Pertanian, Fakultas Pertanian, Universitas Khairun*, ***2***(1), 152–157.

Rahayu, D., Rahayu, W.P., Jenie, H.N., Herawati, D., Broto, W., & Ambarwati, S. (2015). Pengaruh suhu dan kelembaban terhadap pertumbuhan Fusarium verticillioides Bio 957 dan produksi fumonisin B1. *Agritech*, ***35***(2), 153–156. https://doi.org/10.22146/agritech.9401

Rozi, F., Saifudin, S., & Junaidi, J. (2022). Studi erodibilitas tanah pada lahan bekas penambangan tanah (Galian C) di Kelurahan Sedau Kecamatan Singkawang Selatan Kota Singkawang. *Perkebunan Dan Lahan Tropika*, ***12***(1), 9–14.

Saha, S., Sarkar, D., & Mondal, P. (2022). Assessing and mapping soil erosion risk zone in Ratlam District, central India. *Regional Sustainability*, ***3***(4), 373–390. https://doi.org/10.1016/j.regsus.2022.11.005

Sholikah, D.H., Naufal, R., Sigit Wicaksono, K., & Soemarno, S. (2024). Analisis erodibilitas tanah dan hubungannya dengan produktivitas tanaman kopi di Kecamatan Wajak, Kabupaten Malang. *Jurnal Tanah Dan Sumberdaya Lahan*, ***11***(1), 125–134. https://doi.org/10.21776/ub.jtsl.2024.011.1.14

Sugiyono, S. (2013). *Metode Penelitian Kuantitatif, Kualitatif, dan R&D*. CV Alfabeta, Bandung.

Sulistyaningrum, D., Susanawati, L.D., & Suharto, B. (2014). Pengaruh karakteristik fisika-kimia tanah terhadap nilai indeks erodibilitas tanah dan upaya konservasi lahan. *Jurnal Sumber Daya Alam dan Lingkungan*, ***1***(2), 55–62.

Wang, G., Fang, Q., Teng, Y., & Yu, J. (2016). Determination of the factors governing soil erodibility using hyperspectral visible and near-infrared reflectance spectroscopy. *International Journal of Applied Earth Observation and Geoinformation*, ***53***, 48–63. https://doi.org/10.1016/j.jag.2016.08.006

Wischmeier, W.H., & Smith, D.D. (1978). *Predicting Rainfall Erosion Losses – A Guide to Conservation Planning*. Agriculture Handbook No. 537. U.S. Departement of Agriculture, Washington DC. 58p.

Widiyanti, B.L., Susanti, D.R., & Darmawangi, M.A. (2022). Kajian erodabilitas tanah di DAS Palung bagian hulu Kabupaten Lombok Timur. *Geodika: Jurnal Kajian Ilmu dan Pendidikan Geografi*, ***6***(2), 274–284. https://doi.org/10.29408/geodika.v6i2.7072

Yunanda, F., Soemeinaboedhy, I.N., & Silawibawa, I.P. (2022). Pengaruh pemberian berbagai pupuk organik terhadap sifat fisik tanah, kimia tanah, dan produksi kacang tanah (*Arachis hypogaea* L.) di Kecamatan Kediri. *Jurnal Ilmiah Mahasiswa Agrokomplek*, ***1***(3), 294–303. https://doi.org/10.29303/jima.v1i3.2148