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Parameter Analysis of Soil Properties to Determine the Quality of Paddy Soil

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Abstract: Paddy fields in Indonesia are vulnerable to declining quality due to the high management intensity. This study aimed to determine the factors that influence the quality of paddy fields during the eight years of application of compost in the paddy fields. The study used survey methods and field observations. The results of this study indicate that there are 16 minimum variables of the data set being tested. Tests at a significant level of 0.01 indicate a positive or negative correlation of each parameter of soil properties. The results show five main component variables formed and explain the total data variance of 53.62% in determining the quality of paddy fields. The quality of paddy fields can be explained by the five main components formed. The five variables included are soil biological properties, chemical components, macronutrient components, and micronutrient components. These five main components are factors that affect the quality of paddy fields.

Keywords: *Paddy Soil, soil properties, soil quality,*

I. INTRODUCTION

The paddy soil in Indonesia continue to experience degradation, reaching 100 thousand hectares per year [1] .Degradation of paddy fields occurred both in terms of quantity and quality decreased significantly. The results of the study of [2] showed that about 65% of paddy land in Indonesia had C-organic content below the critical limit (<2%), and only 35% had C-organic content >2%. Paddy soils are vulnerable to quality degradation due to the high intensity of management [3]. Intensive long-term management of paddy fields, with high input of chemicals and technology in paddy fields, is the most significant factor causing the decline in the quality of paddy fields .

Degradation of soil quality can result in loss of soil resources and soil function in the long term [4], [5]. Therefore, it is necessary to evaluate the impact of measurable agricultural land management practices. The carrying capacity of the soil has many functions, namely as a provider of ecological services, which includes maintaining the availability of food production [6]. Maintain the varied functions of soil [7] soil quality is the foundation. Soil quality is highly dependent on the interaction of physical, chemical, and

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biological characteristics and proper assessment of soil quality requires the measurement of many parameters [6], [8]. Maintaining soil quality in ideal conditions is quite challenging due to supporting factors such as climatic factors, soils, interacting plants [9]. Especially in paddy fields, the practice of silting and land preparation is a condition that significantly affects the quality of the soil physically, chemically, and biologically biologi [10], [11].

Integrated information of all soil quality indicator parameters by developing a soil quality index is one of the tools for implementing a management system on agricultural land [12]. When land management focuses more on sustainable management and focuses on increasing yields, the soil quality index can be seen as the leading indicator for sustainable agricultural land management. Soil quality cannot be measured directly, so it is necessary to determine physical, chemical, and biological indicators, which will directly provide a comprehensive measurement of soil quality, known as drinking data set (MDS) [13], [14]. The most commonly used soil quality approach for soil quality development.

Soil quality indicators must be selected according to the desired soil function, and threshold values must be identified based on existing field conditions to obtain a site-specific soil quality index. Selection of soil quality indicators using expert opinion, based on statistical procedures, or a combination of both to obtain a minimum data set (MDS). This study aimed to determine the factors that influence paddy soil quality during the eight years of application of compost in the paddy fields of Salassae Village, Bulukumpa District, Bulukumba Regency, South Sulawesi Province, Indonesia

II. MATERIAL AND METHODS

2.1 Sampling Site

The location of this research was carried out in the village of Sallasae, Bulukumba Regency, with a distance from the capital city of South Sulawesi province as far as 184 km, which is geographically located at position 120^{o}11'39.252"E – 5^o 22'24.108"S. The research location has rainfall above 1400 - 2500 mm/year with a temperature of 23.82^{o}C - 27.68^{o}C and is a lowland with entisols and inceptisols soil types, with an average slope of flat (slope degree 0 – 8 %). The dominant type of land use is 113 hectares of Paddy soil. The agricultural system at the research site is rain-free rice fields that carry out conventional cultivation systems and have begun to switch to natural cultivation systems for almost ten years. Rice fields at the research site have been cultivated for about 50 years. Most rice fields in Indonesia are located in alluvial plains constantly inundated with water, either from rainwater, overflowing rivers, or shallow groundwater. The relief/topography conditions are low. Does not allow the movement of water under the soil solum, then the illuviation horizon of Fe and Mn or the plow tread layer is difficult to form.

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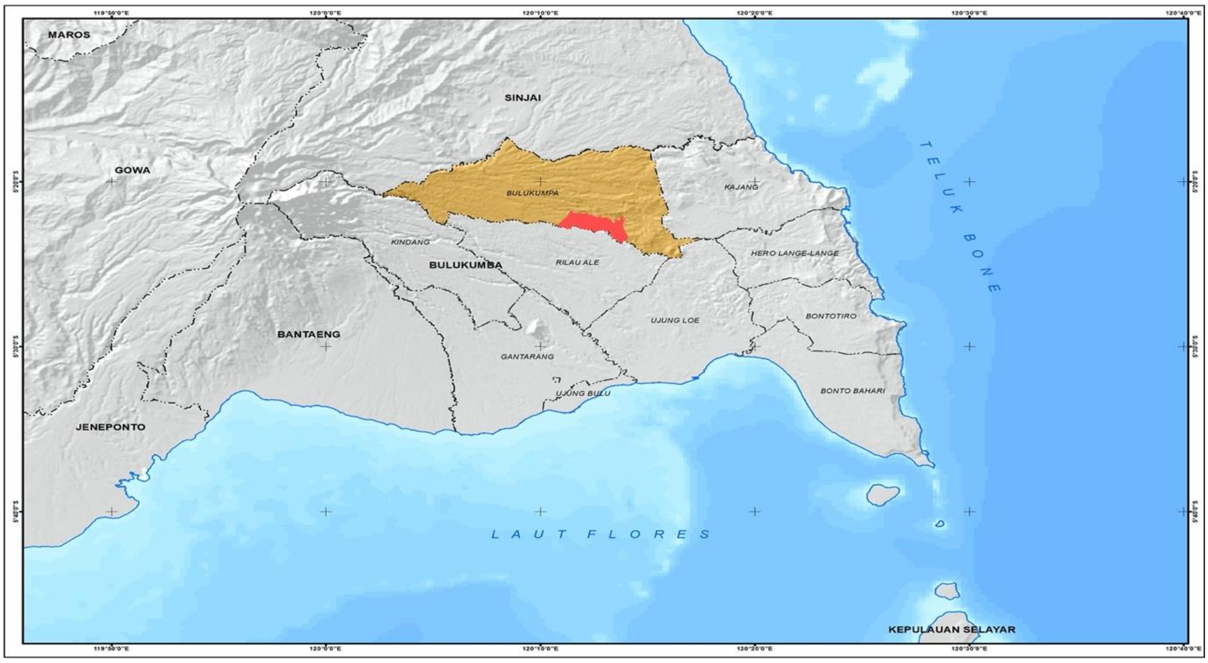

Fig 1**.** Geographic locations of soil sampling site , Salassae Village, Bulukumpa District, Bulukumba Regency, South Sulawesi Province. Indonesia

2.2 Soil sampling

The sampling point of soil sampling using the purposive sampling method namely the sampling point, has been determined. The sampling location was in the rice field area at the application level of organic fertilizer (compost) in different years (0 years – 8 years). Soil samples were taken at a depth of 0 -15 cm and 15-30 with three repetitions at each point. Analysis of the soil description in the field uses two methods, namely the soil drilling method, which is intended to determine the thickness of the solum thickness of the paddy field soil. While the soil morphology data through the description of the soil profile. Soil sampling is devoted only to the topsoil and subsoil layers with a thickness of 0-30 cm and analysis to determine soil quality.

2.3 Soil physicochemical analysis

The disturbed soil samples were air-dried and filtered through a 2 mm sieve, before being brought to the laboratory. The selected chemical, physical and biological attributes of the soil were measured using the following standard methods: Soil texture components (sand, silt, and clay content) with a hydrometer (Klute, 1986); soil organic carbon (OC) by wet oxidation method (Page et al., 1982), cation exchange capacity (CEC) by ammonium acetate transfer method (Page et al., 1982), total nitrogen (TN) by Kjeldahl method (Page et al., 1982). al., 1982), al., 1982); available phosphorus (Pav) by the Olsen method (Olsen et al., 1954); and available potassium (Kav) by extraction with ammonium acetate (Chapman and Pratt, 1962). Calculate the number of soil microbes using the total plate count (TPC) method. Analysis of soil properties was carried out in the soil fertility laboratory, majoring in soil science, Faculty of Agriculture, Hasanuddin University. The study used a field observation survey approach to collect primary data (regional biophysical

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data and data on soil properties and characteristics). The soil quality indicators were approached through laboratory analysis.

2.4 Data Analysis

Statistical analysis using JAPS 014.6 application (open source). Pearson product difference correlation test was used for correlation analysis. Correlation analysis was used to measure the relationship between the Minimum Data Set (MDS) indicators of soil parameters and soil quality. Principal component analysis (PCA) using the MVSP 3.2 application. PCA analysis was performed to reduce variables that did not have a significant effect. So that from 16 variables with 30 cases of variable MDS parameters of rice fields in the research location in the data set, new variables will be selected representing 16 original variables to form the factors that have the most or most significant influence.

III. RESULTS AND DISCUSSION

The monitoring data set is separated into two main sections—data for the surface soil layer (0–15 cm surface sampling) and the subsurface layer (15–30 cm depth). Overall, 16 samples from 5 different sampling sites were included in the data analysis. The results of the MDS correlation analysis of soil parameters for physical, chemical, and biological properties of paddy soil, Correlation relationships at five points in the research location with different applications of compost use are presented in (Figure 1).

Based on the Person Correlation analysis (figure 1), the correlated parameters were observed in 16 variables with 30 cases of the MDS parameter variable for paddy fields in the research location. Positive/negative correlation of a less significant relationship sample with a very strong relationship (r<0.00-0.90). Several variable values from MDS indicate a correlation. The strongest or very significant positive correlation is shown between PH and C- organic matter, nitrogen, and organic matter. Furthermore, a very strong relationship was also shown for total P with Ca, KB with Ca. The strongest or very significant negative correlation is shown in soil texture

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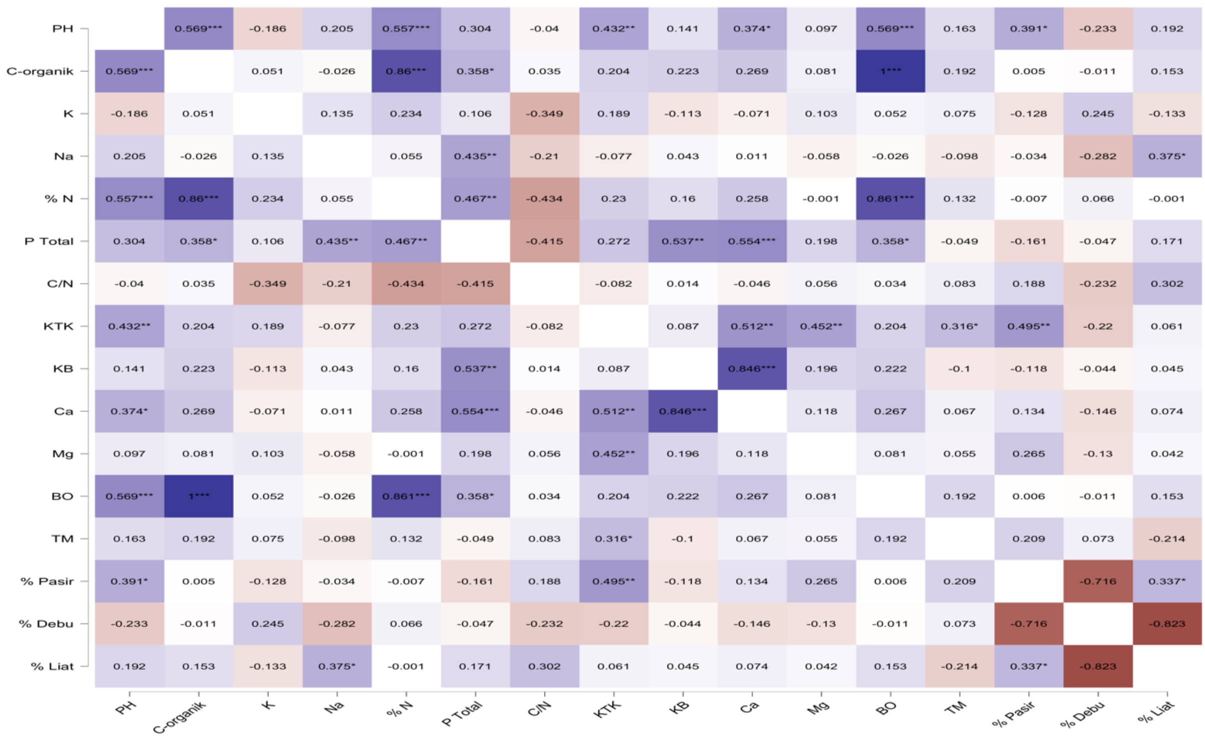

Fig 1. Pearson Correlation Analysis between 16 MDS parameters of Physical, Chemical, and Biological soil

In principal component analysis, 16 soil properties are considered for analysis. The Main Components analysis successfully reduced the component variables into five components (PC1, PC2, PC3, PC4, and PC5). These variables affect the quality of paddy soil at the research site. The first five main components have an Egien value > 1 (Figure 2; Table1), Contributing to 53.62% of the total variance of all existing data.

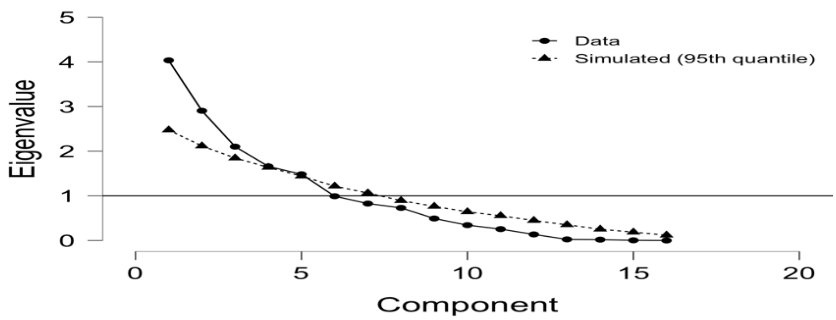

Fig 2. Egien value formed from each component

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TABLE 1. Results of Principal Component Analysis of lowland soil quality in Salassae Village, Bulukumba Regency, South Sulawesi ProvinceFigure 2. EgienValue value formed from each component.

Soil parameters	PC1	PC2	PC3	PC4	PC5	Uniqueness
PH	**0.773**	0.091		-0.082		0.385
K		0.293	-0.300	-0.061	**0.654**	0.393
Na	0.071	0.129	0.457	**-0.568**	0.396	0.290
N	**0.707**	0.495	-0.342	-0.285		0.057
P Total		**0.738**	0.482	-0.062	0.115	0.206
C/N	0.123	-0.626		0.179	**-0.506**	0.302
KTK	**0.652**	-0.135		0.471	0.407	0.167
KB	0.177	0.561	**0.602**	0.306	-0.309	0.102
Ca	0.474	0.427	**0.507**	0.426	-0.144	0.133
Mg	0.283		0.135	0.480	0.345	0.550
BO	**0,831**	0,179	-0,349	-0,201	-0,254	0,050
TM	0.193	0.073	-0.318	0.375	0.123	0.700
% Pasir	0.561	**-0.649**		0.197	0.249	0.162
% Debu	-0.508	**0.646**	-0.433	0.174	-0.135	0.089
% Liat	0.403	-0.433	**0.525**	-0.439		0.181
Eigenvalue[a]	4.034	2.905	2.101	1.660	1.483	-
% Tot Varian	25,2%	18,2%	13,1%	10,4%	9,3%	-
Cumlative Var	25,2%	43,4 %	56,5%	66,9%	76,1%	**53,62** %

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In table 1, five new variables (principal components) have more than one eigenvalue. The first principal component (PC1) has an eigenvalue of 4.038. The first principal component explains 25.2% of the data variance, which has a strong positive charge with a value (r > 0.60) obtained in organic matter (0.83), pH (0.77), Nitrogen (0.70), and CEC (0.65). We identified this as a component of soil biochemical function because all soil properties contained in this component were significantly correlated (P<0.001) with the existing variables (Table 1). The first principal component (PC1) considers soil chemistry indicators as indicators that become the main consideration in determining soil quality in paddy fields in Salassae, Bulukumba Regency. Soil chemical components play the most significant role in determining the properties and characteristics of the soil in general. Soil chemical components determine soil fertility and soil quality through active ingredients from the soil that play a role in absorbing and exchanging ions in the soil[6], [15]

The second main component (PC2) explained 43.4% of the data variance (table 3) and was identified as a macronutrient component having a strong positive charge of P (0.738), and a group of soil physical properties represented by the percentage of dust (0.64). The addition of organic matter can increase the availability of P in the soil. Organic matter directly affects the availability of phosphorus. The direct effect produces organic acids that can react with Al, Fe, and Ca to form stable ions and release them. The increase in available P and total P was thought to be due to soil pH. Another variable on PC3 which shows a strong positive charge is the base saturation component of the earth (0.60). The total variance of the data represented is 56.5%, with an egian value of 2.10. KB components provide easy release of adsorbed cations for plants. Base saturation (KB) of soil is the percentage of the total CEC occupied by basic cations, namely Ca, Mg, Na, and K, to the total number of cations bound and exchangeable by colloids.

The fourth main component (PC4) explains no very strong relationship because all r values < 0.60. there are still components that show a moderate negative relationship (intermediate) with r values (0.40-0.59). These variables are Na (-0.56). This component is the micronutrient component. The Na+ relationship, as shown in the analysis above, the Na+ relationship is because these cations are easily washed out by percolation water and released into the soil horizon. The fourth principle component explains 66.9% of the data variance, with an egian value of 1.66. The minimum nutrients and other desirable elements have no role in increasing the yield. According to Liebig's law, if a nutrient is at a minimum level, the yield will be a function of that element, and other elements cannot perform the function of the restricted element [16].

The results of the fifth principal component of PC5 explain that the potassium component (0.65) has a very strong relationship with the value of r > 0.60. *Potassium* is a mobile nutrient absorbed by plants in the form of K+ ions in the soil. Plants need potassium as a catalyst to activate 60 enzymes in plants. The fifth main component of PC5 explains that five of these main components can contribute to the total data variance of 76.1% of the total five components of the data analyzed. The most influential soil quality is that all the main components have more than one egien value (Figure 2;Tabel 1).

The use of cluster analysis aims to group the data obtained in the field into several classes with the criteria for grouping the same characteristic data in one area with different characteristics. The difference between objects can be measured using the Euclidean distance measure. The closer or smaller the Euclidean distance between the characteristics of the parameters. The more similar the characteristics of these parameters.

The clustering results obtained 6 clusters and ten accessions (Table 2; Figure 3). One accession was found in Cluster I (lp2.8) and II (lp2.6). In Cluster III, three accessions, lp1.4, lp.2.0, and lp2.1, were found.

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In Cluster V, one accession lp.2.4 was found. In the fourth Cluster, two accessions, lp.1.8 and lp.1.0, were found.

TABLE 2. Groups of 10 accessions from 6 clusters according to the analysis of Soil Properties Parameters

Claster	Accessions
I	lp2.8
II	lp2.6
III	lp1.4, lp.2.0, lp2.1
IV	lp.2.2, lp.1.6
V	lp.2.4
VI	lp.1.8, 01 lp.1.0

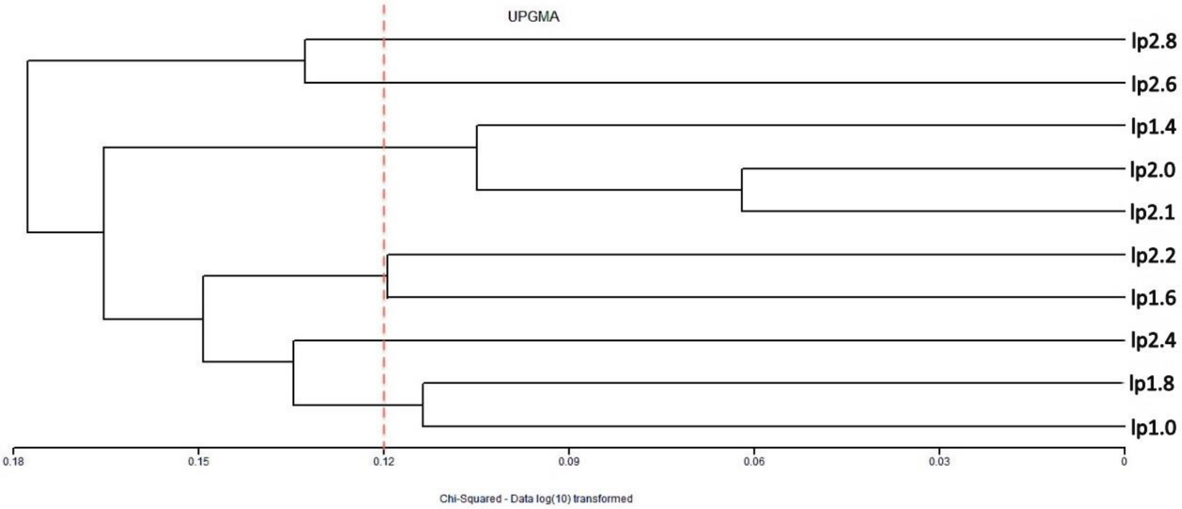

Fig 3. Cluster analysis shows the relationship between 10 accessions of soil properties parameters (physical, chemical, and biological properties)

The relationship of all components of the analysis can be seen (figure 3), which shows the relationship of each component that is most related and influential in determining the most related parameter in determining the quality of paddy fields at the research site. Consider the consistency of soil properties such as soil quality indicators and the performance of these indicators when interpreted with PCA. Based on cluster analysis, management actions carried out at the research site obtained six clusters. The cluster formed shows that the difference in management applied to the research location affects the quality of paddy fields. There is a limited correlation, pH, total phosphorus texture, total Nitrogen, potassium, or organic matter with other variables in our dataset. They indicated that macro or micronutrients are mainly related to organic matter availability—composition of organic matter and potential in influencing CEC and base saturation. Low soil quality will lead to soil degradation [3], [17] describe the comprehensive nature of soil quality assessments, allowing for estimating environmental risk, with quality deterioration seen as a result of soil degradation[18].

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VI. CONCLUSION

At the minimum data set (MDS) there are 16 variables of lowland soil quality, PC1 (25.2%), PC2 (43.4%), PC3 (56.5%), PC4 (66.9%) and PC5 (76.1). %) in determining the quality of paddy fields. The five new variables formed in the main component can explain the total variance (cumulative percent of variance) of 53.62%, which means that the quality of paddy fields can be explained by the five variables formed. The five variables formed are components of chemical and biological properties (PC1), components of wet soil saturation (PC2), macronutrient components (PC3), and components of bases (PC5). These five main components affect the qualiy of paddy soil in the research location. The cluster formed shows that the difference in management applied to the research location affects the quality of paddy fields.

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REFRENCES

[1] D. Setyorini, S. Rochayati, and I. Las, "Pertanian pada Ekosistem Lahan Sawah," *Balai Besar Litbang Sumberdaya Lahan Pertanian*, no. 2, pp. 27–45, 2010, [Online]. Available: http://www.litbang.pertanian.go.id/buku/membalik-kecenderungan-degrad/

[2] R. Saraswati, E. Husein, and R. Simanungkalit, "Metode Analisis Biologi Tanah," *Balai Besar Litbang Sumber Daya Lahan Pertanian*, 2007.

[3] Z. Liu, W. Zhou, J. Shen, S. Li, and C. Ai, "Soil quality assessment of yellow clayey paddy soils with different productivity," *Biology and Fertility of Soils*, vol. 50, no. 3, pp. 537–548, 2014, doi: 10.1007/s00374-013-0864-9.

[4] S. Widawati, "THE EFFECT OF SALINITY TO ACTIVITY AND EFFECTIVITY PHOSPHATE SOLUBILIZING BACTERIA ON GROWTH AND PRODUCTION OF PADDY," *KnE Life Sciences*, vol. 2, no. 1, 2015, doi: 10.18502/kls.v2i1.227.

[5] A. M. Breure, "Soil biodiversity: Measurements, Indicators, Threats and soil functions," *International Conference on Soil and compost eco-biology*, pp. 83–96, 2004, doi: 10.1016/B978-0-12-385026-3.00010-3.

[6] F. M. Seaton *et al.*, "Soil health cluster analysis based on national monitoring of soil indicators," 2020, doi: 10.1111/ejss.12958.

[7] P. Xue, B. Minasny, and A. B. McBratney, "Land-use affects soil microbial co-occurrence networks and their putative functions," *Applied Soil Ecology*, vol. 169, Jan. 2022, doi: 10.1016/J.APSOIL.2021.104184.

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Article History: Received: 10 April 2022 Revised: 18 May 2022 Accepted: 30 June 2022 Publication: 25 July 2022

[8] A. Maria Astel, L. Chepanova, and V. Simeonov, “Soil Contamination Interpretation by the Use of Monitoring Data Analysis”, doi: 10.1007/s11270-010-0539-1.

[9] M. F. Kurniawan, M. L. Rayes, and C. Agustina, “Analisis Kualitas Tanah Pada Lahan Tegalan Berpasir Di Das Mikro Supiturung, Kabupaten Kediri, Jawa Timur,” *Jurnal Tanah dan Sumberdaya Lahan*, vol. 8, no. 2, pp. 527–537, 2021, doi: 10.21776/ub.jtsl.2021.008.2.23.

[10] Rayers M. lutfi, “genesis tanah sawah.pdf,” 2000.

[11] R. Neswati, B. Dirgantara, H. Putra, M. Jayadi, and A. Ardiansyah, “Using of Oil Palm Empty Fruit Bunch Compost and Mycorrhizae Arbuscular for Improving the Fertility of Nickel Post-Mining Soil,” vol. 23, no. 2, pp. 86–96, 2022.

[12] A. C. R. de Lima, W. Hoogmoed, and L. Brussaard, “Soil Quality Assessment in Rice Production Systems: Establishing a Minimum Data Set,” *Journal of Environmental Quality*, vol. 37, no. 2, pp. 623–630, 2008, doi: 10.2134/jeq2006.0280.

[13] L. Martunis, S. Sufardi, and M. Muyassir, “Analisis Indeks Kualitas Tanah di Lahan Kering Kabupaten Aceh Besar Provinsi Aceh,” *Jurnal Budidaya Pertanian*, vol. 12, no. 1, pp. 34–40, 2016.

[14] G. Tóth, T. Hermann, M. R. da Silva, and L. Montanarella, “Monitoring soil for sustainable development and land degradation neutrality,” *Environmental Monitoring and Assessment*, vol. 190, no. 2, 2018, doi: 10.1007/s10661-017-6415-3.

[15] B. A. Stewart and L. Rattan, *Principles of sustainable soil management in advances in soil science*. 2013.

[16] C. S. Nautiyal, “An effcient microbiological growth medium for screening phosphate solubilizing microorganisms C.,” *Tageszeitung*, vol. 170, no. 9531, p. 1, 2011.

[17] E. K. Bünemann *et al.*, “Soil quality – A critical review,” *Soil Biology and Biochemistry*, vol. 120, no. September 2017, pp. 105–125, 2018, doi: 10.1016/j.soilbio.2018.01.030.

[18] D. de La Rosa and R. Sobral, “Soil quality and methods for its assessment,” *Land Use and Soil Resources*, pp. 167–200, 2008, doi: 10.1007/978-1-4020-6778-5_9.