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Soil Function Analysis in Determining the Soil Quality Index of Paddy Fields in Salassae Village, Bulukumba Regency, South Sulawesi Province, Indonesia

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ABSTRACT

Background: The quality of the function of paddy fields in Indonesia is strongly influenced by the high intensity of the level of management. Degradation of soil quality with improper management practice result in the loss of land resources and functions in the long term.

Methods: This study uses survey methods, and the determination of soil quality index is calculated based on the criteria of Mausbach and Seybold (1998) modified.

Result: This research shows that the overall soil quality at the research location is still quite good. Locations 1,2,3 and 4 indicated a soil quality index with reasonable criteria, while location five indicated a decrease in soil quality index by 0.1% with moderate criteria. The decline in soil quality shown at location five was due to the level of management behavior in giving compost using only local knowledge. The results of this study indicate the main limiting level of soil quality at the research site is the availability of nitrogen and C-organic in the soil.

Key words: Compost management, Paddy field, Soil quality.

INTRODUCTION

In Indonesia, Paddy fields are land with intenseve management system. The intensity of intense soil management will significantly affect the function of the soil from a physical, chemical, or biological perspective. The carrying capacity of the soil has many functions,

whereas a provider of ecological services includes maintaining the availability of food production (Li *et al.*, 2020). The function of the soil is very varied, soil quality is the foundation (Laishram *et al.*, 2012). Degradation of soil quality can result in loss of land resources and functions in the long term (Doran and Zeiss, 2000). Therefore, it is necessary to calculate the impact of agricultural management practices (Akinbile and Sangodoyin, 2011).

Soil quality is highly dependent on the interaction of physical, chemical, and biological characteristics and proper soil quality assessment requires the measurement of many parameters (Martunis *et al.*, 2016). Challenges remain in assessing soil quality because the standards set in assessing soil quality vary widely, both spatially and temporally (Liu *et al.*, 2014). The productivity of paddy fields can decrease due to excess and lack of nutrients because the harvest carried more than the nutrients provided through fertilization or the addition of nutrients from irrigation water (Burauel and Baßmann, 2005). The excess of certain fertilizers and the lack of other fertilizers due to imbalanced fertilization and a decrease in soil organic matter content. This degradation threatens rice yields' quantity (productivity) and quality (Seaton *et al.*, 2020).

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Determining soil quality is very difficult because soil quality and production are very complex and depend on complex relationships between soil attributes and other external factors (Yimer, 2022). Soil quality cannot be measured directly, so it is necessary to determine physical, chemical, and biological indicators (Hadija *et al.*, 2018), which will directly provide a comprehensive measurement of soil quality, known as minimum data set (MDS). An MDS with the right indicators can reduce the need to define many indicators (de Lima *et al*., 2008) and should adequately represent the complete data set (Sarbu and Pop, 2005). Evaluating the status of paddy soil quality at different management levels will be important to develop sustainable paddy land use management to increase yield production (Sewnet *et al*., 2020; Turamyenyirijuru *et al*., 2019).

Evaluation of soil quality needs to be explicitly developed on productive lands such as agricultural land. Anthropogenic lands such as paddy fields that were constantly inundated or this condition is suscept ible to changes in physical, chemical, and biological properties (Choudhury and Kennedy, 2005). Rice fields are very vulnerable to soil quality degradation due to management practices (Haefele *et al*., 2014). The limited evaluation of soil quality functions, which has been limited to the scientific stage, currently requires an approach method that must be easily understood at the farmer level. Farmers have practical knowledge from daily experience in the field, and farmers can adjust or adapt their agricultural land management (Prayitno *et al*., 2019). Specific local information about land conditions and land management systems is needed to conduct a comprehensive evaluation of soil quality functions. Knowing the quality of paddy fields will help the application and adaptation of technology in restoring degraded paddy fields. The application and adaptation of technology by utilizing agricultural resources need to be carried out to maintain the continuity of high soil productivity.

MATERIALS AND METHODS

Study area

The location of this research was carried out in the village of Sallasae, Bulukumba Regency with 184 km from the provincial capital of South Sulawesi, which is geographically located at the position of 120011′39.252″E-5022′24,108″ S. This research was conducted in April - August 2021. Analysis of soil properties (physical, chemical and biological properties of soil) 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 data and data on soil properties and characteristics). The soil quality indicators were approached through laboratory analysis.

Soil sampling and laboratory analysis

The sampling point of soil sampling using the purposive sampling method is the point that has been determined in the paddy field area at the level of application of organic fertilizer in different years (0 years-8 years). Soil sampling was repeated three times at each point with a 0-30 cm depth. Analysis of the soil description in the field uses two methods, namely the method of soil boring and soil profiling. Sampling points of soil sampling using purposive sampling method, namely the point has been determined in the paddy field area at the level of organic fertilizer application in different years (0 years - 8 years) with three repetitions at each point. Analysis of the description of the soil in the field uses two methods, namely the boring soil method, which is intended to determine the thickness of the soil solum in the paddy fields. While the soil morphology data through the description of the soil profile. Soil sampling was devoted only to the topsoil and subsoil layers with a thickness of 0-30 cm and analysis to determine soil quality. Soil quality analysis was based on physical, chemical and biological soil parameters. The selected chemical, physical and biological attributes of the soils were measured using the following standard methods: texture by hydrometer method, pH H_2O with soil: water suspension (1:2.5), Soil Organic Carbon by Walkley and black method, total N by Kjeldahl method, available P by the Bray method (acidic soil) and Olsen method (alkaline soil), and Ca, Mg, Na, K and cation exchangeable capacity with 1 N ammonium acetate and 10% sodium chloride extraction. The number of soils microbs ware Calculated by (Skinner, F.A., Jones, 1952) the total plate count (TPC) method.

Data analysis of paddy soil quality index

The soil quality index was calculated based on the criteria of (Seybold *et al*., 1998) modified. The steps for calculating the index were carried out as follows: The weighted index was calculated by multiplying the weight of the soil function (weight 1) by rooting medium weight (weight 2) and root depth weight (weight 3). For example, the weight index for porosity is obtained by multiplying 0.40 (weight 1) by 0.33 (weight 2) by 0.60 (weight 3) and the result is 0.080. The score is calculated by comparing the observed data from the soil indicator and the assessment function (Sarbu and Pop, 2005). Scores ranged from 0 for poor condition and 1 for good condition. Scoring can be done through interpolation or linear equations by the set range based on values or the data obtained. According to Masto 2007, the linear scoring function (FSL) is:

$$Y = \frac{(x - x2)}{(x1 - x2)}$$

$$(Y) = \frac{1-(x - x2)}{(x1 - x2)}$$

Where,

Y: The linear score.

X: The value of soil properties.

X2: The upper limit value.

X1: The lower limit value.

Soil quality index is calculated by multiplying the weight index and the score of the indicators. Soil quality assessment uses the soil quality index equation (Vestergaard *et al*., 2017):

$$SQI = \sum_{t-1}^{n} Wi \times Si$$

Where,

SQI: Soil quality index;

S: Scores on selected indicators;

Wi: Weight index,

n: Number of soil quality indicators.

Furthermore, the soil quality index values are categorized into five criteria classes, as shown in Table 1.

Spatial analysis analysis of rice soil quality distribution

Mapping of paddy soil quality index was made using spatial interpolation technique. The interpolation method chosen is Co-Kriging using the ARGIS 10.3 program.

RESULTS AND DISCUSSION

Preserving biological activities

Weight The highest preservation of biological activity was obtained at the third location, namely 0.24 and the lowest at the first location, 0.20 (Fig 1). large amounts of biomass each harvest season. As explained (Williams and Joseph 1976) The main problems in farming in the wet tropics are low nutrient content of the soil, the availability of soil organic matter, and the ability of the soil water content.

Regulating and distributing water

The soil functions as regulation and distribution of water using the percentage of silt and clay (Fig 2). The highest water regulation and distribution function was achieved at location fifth (0.234) and the lowest at location sixth (0.153). This function was greatly influenced by the condition of the texture of the soil. The finer or higher the clay content of a soil, the higher the ability to store water. Soil water content ware primarily determined by the soil's capillarity and pore

Table 1: Paddy soil quality criteria based on its function.

Soil function	Weight	Soil indicator	Unit	Weight	Weight	Weight indexes	Rating function			
							Lower limit		Upper limit	
	1			2	3	(1x2x3)	x1	y2	x1	y2
Preserving biological activities	0.4	A. Rhizosper area		0.33		-				
		Root deep	cm		1	0.13	20	0	80	1
		B. soil moisture		0.33		-				
		SOC	%		0.5	0.05	10	0	2	1
		L + C	%		0.5	0,05	0.6	0	100	1
		C. Fertility		0.33		-				
		pH			0.1	-	4	0	8.2	1
		Av.P	ppm		0.2	-	4	0	10	1
		Ex.K	cmol kg^{-1}		0.2	-	0.05	0	1	1
		SOC	%		0.3	-	0.6	0	2	1
		T-N	%		0.2	-	0.15	0	2.5	1
Regulating and distributing water	0.3	L + C	%	1		0.30	0	0	100	1
Filter and buffer function	0.3	L + C		0.6		0.18	0	0	100	1
		Microbiological processes		0.4		-				
		SOC	%		0.4	0.05	0.045	0	2	1
		T-N	%		0.4	0.05	0.045	0	2.5	1
		Total microbes	TPC/gram		0.2	0.02	10^1	0	10^9	1

*kriteria Mausbach dan Seybold (1998) modified.

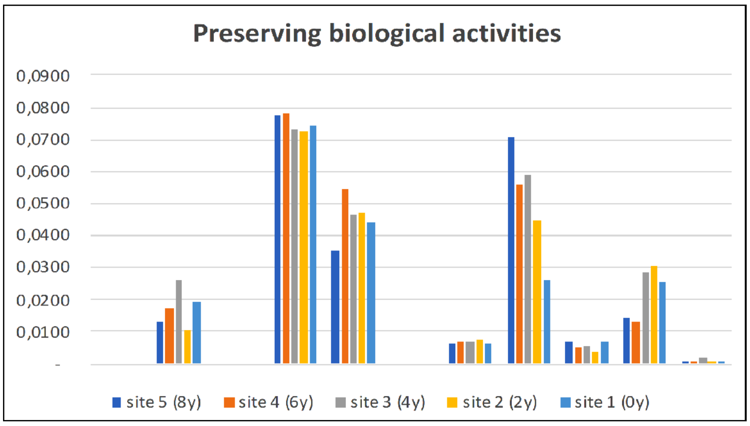

Fig 1: Preserving biological activities in paddy soil.

size distribution. At higher potentials, soil water content was determined by soil texture.

Filtering and buffering

The function of the soil as a filter and buffer, in this case, takes into account the function of texture (loam+clay) and microbiological processes, including total microbial, total N, and total soil organic carbon (Fig 3). This study indicates that the highest filter and buffer are locations three and one, with a weighted index value of 0.20. While the lowest weight index value ware found at location fifth (0.13) the low index weight at location fifth was due to the low total Nitrogen value and soil organic carbon content. Las and Setiorini (2010) reported that ±73% of agricultural land in Indonesia has low soil C-organic content (less than 2%). The low content of soil organic carbon will affect soil microbial activity because

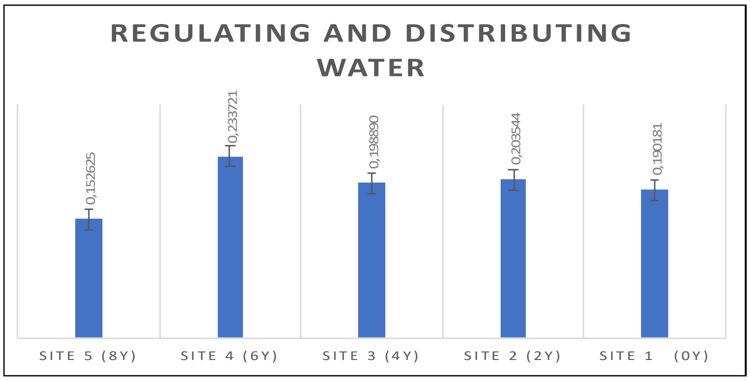

Fig 2: Regulating and distributing water in paddy soil.

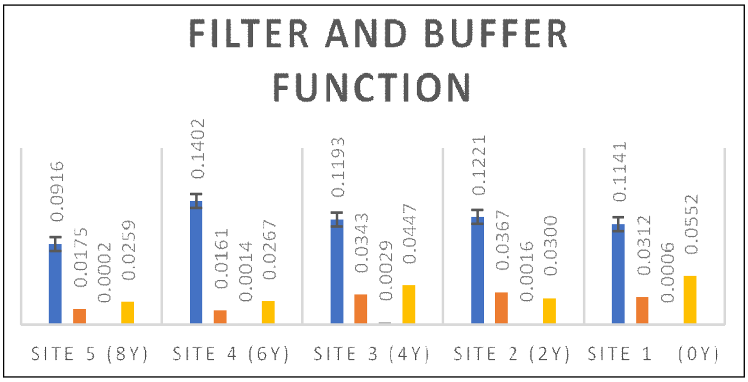

Fig 3: Filter and buffer functions in paddy soil.

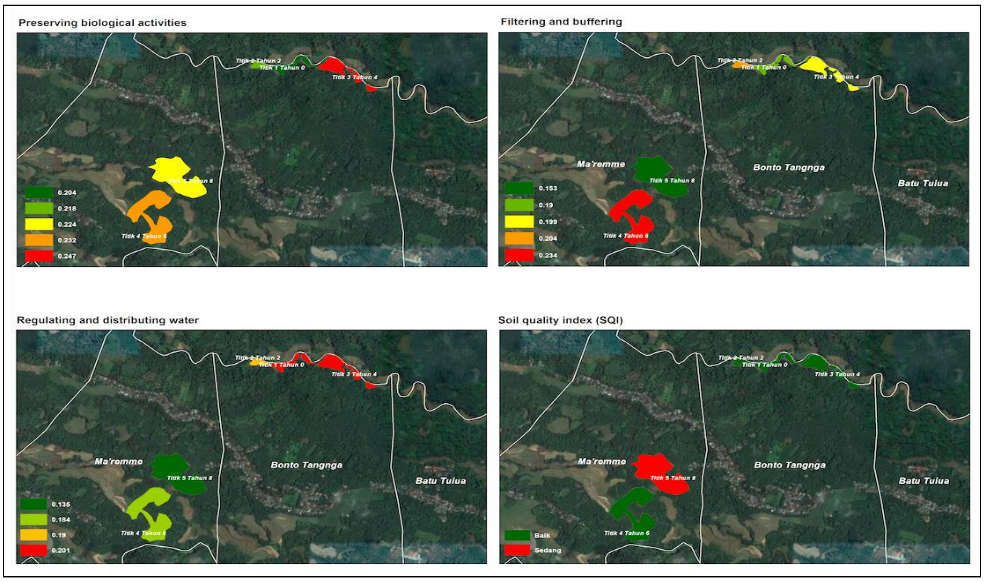

Fig 4: Distribution of the soil quality index in Salassa Village, Bulukumba Regency.

Table 2: Paddy soil quality based on its function.

Soil function	Soil quality index				
	Site 5 (8y)	Site 4 (6y)	Site 3 (4y)	Site 2 (2y)	Site 1 (0y)
Preserving biological activities	0.224	0.232	0.247	0.218	0.204
Regulating and distributing water	0.153	0.234	0.199	0.204	0.190
Filtering and buffering	0.135	0.184	0.201	0.190	0.201
Total	0.51	0.65	0.65	0.61	0.60
Description	Moderate	Good	Good	Good	Good

the microbial population in the soil will increase if a carbon source is available for energy. Microbes need a regular supply of active organic matter to survive in the soil.

Paddy soil quality index

The results of the soil quality index analysis using the soil function approach showed the distribution of soil quality at the study site (Table 2; Fig 4). The results of the soil function analysis show that the soil quality index values with moderate criteria are at locations 1,2,3 and 4. The soil quality index values with moderate criteria are at location five. In general, the soil quality is still quite good at the research site. However, the thing that must be observed is the decrease in the soil quality index at location five where this location is a location where the application of compost (organic) fertilizer is quite long from all locations. The decrease in soil quality by 0.1% was thought to be due to the high intensity of management, farmer behavior, management, quality/quantity and variations in the amount of compost and the amount/diversity of microbes. Meanwhile, Sanchez (1976) stated that the potential for soil quality degradation in the tropics is quite vulnerable because climatic factors cause high and fast rates of decomposition and leaching of nutrients. (Subowo and Purwani, 2013), Uncontrolled farming system management triggering the degradarion of soil quality.

CONCLUSION

The results of the soil function analysis show that the soil quality index value with good criteria is at locations 1,2,3 and 4 the soil quality index value with moderate criteria wares found at location five. In general, the soil quality is still quite good at the research site. However, the thing that must be observed is the decrease in the soil quality index by 0.1% at location five where this location is a location where the application of compost (organic) fertilizer is quite long from all locations. Furthermore, we suggest conducting further studies on farmers' behavior and their role in influencing the quality of paddy fields at the research site.

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