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Annual Flood Phenomenon and Fertility Status of Rice Soil in The Coastal Area of Bengkulu

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ABSTRACT

The annual occurrence of flooding in Bengkulu City results in widespread damage, affecting various aspects of community life, including social, economic, and agricultural conditions. Furthermore, paddy soil was one type of land that has been significantly impacted on climate change, especially flood occurrence. The research aimed to analyze the fertility status of soil affected by annual flood disasters, evaluating, and mapping the distribution of soil fertility status. The methods used survey, where soil sampling used purposive random sampling. Further evaluation of soil fertility status is in accordance with technical instructions from the Soil Research Center, Bogor (1995). This research was conducted in June – August 2023. The result showed that soil CEC value from each sampling point was classified as high with values ranging from 28.15 me 100 g^{-1} to 39.83 me 100 g^{-1}. The base saturation value was classified as very low to moderate with values ranging from 11.49% to 40.08%. Soil organic C was classified as moderate to very high with values ranging from 2.42% to 5.97%. The soil phosphorus content was classified as very low to low with values ranging from 2.69 mg 100 g^{-1} to 12.11 mg 100 g^{-1}. The potassium content was classified as very low with values ranging from 0.14 mg 100 g^{-1} to 1.43 mg 100 g^{-1}. According to these data, the flood phenomenon has a significant impact on soil fertility. The soil fertility status at the research location is classified as low. Soil fertility parameters which are limiting factors in the status of soil fertility are phosphorus, potassium, and pH. So, it is necessary to add P and K fertilizer to improve the soil fertility status.

Keywords : evaluation, floods, mapping, soil fertility

INTRODUCTION

Climate change is increasingly leading to extreme weather events, particularly affecting coastal areas like Bengkulu City. Geographically, Bengkulu City directly borders the Ocean Indies, making it susceptible to direct impacts from oceanic waves and currents (Meinita *et al*., 2022). Studies by Putra *et al*. (2015) also highlight the significant threats posed by climate change to coastal regions, including changes in rainfall patterns, increased flooding, droughts, and rising sea levels (Nuraisah & Kusumo, 2019; Hidayat, 2023), as well as decreased agricultural productivity (Wihardjaka *et al*, 2020).

The annual occurrence of flooding in Bengkulu City results in widespread damage, affecting various aspects of community life, including social, economic, and agricultural conditions. Floods often lead to crop failures, impacting the income of farmers (Adib, 2014 ; Sumastuti & Pradono, 2016; Utami *et al*, 2020). Additionally, access disruptions caused by flooding hinder economic and social activities, resulting in damage to infrastructure and a decline in public health (Santri *et al*., 2020; Susilawati, 2021).

Agricultural areas bear a significant brunt of the damage caused by flooding, resulting in substantial losses for farmers. Floods bury rice plants in mud, leading to failed harvests, while also causing soil erosion and a decline in soil fertility (Rihi *et al.,* 2022; Sihaloho & Sembiring, 2019). Furthermore, flooding alters soil pH and nutrient levels, affecting the productivity of paddy fields (Akpoveta *et al*., 2014).

Given the profound impact of flooding on coastal agricultural areas like Bengkulu City, there is an urgent need to manage paddy fields to enhance rice production and preserve soil fertility. Understanding the spatial distribution and fertility status of rice fields post-flood is crucial for informing strategies to improve agricultural productivity in the region.

MATERIALS AND METHODS

General description of research locations

This research was carried out from June to August 2023 in rice fields Rawa Makmur, Muara Bangkahulu District, Bengkulu City. Area map study presented in Figure 1.

The rice fields were placed at an altitude of 11.19 meters above sea level with 8.7 ha in area (BPS, 2020) and borders with the Air Bengkulu River. This rice field uses the system of cistern rain (non- irrigation) so it really depends on the season of rain. Apart from rice fields, there are also plantations owned by palm oil and fishpond inhabitants.

Soil surveying and sampling

This research was carried out using a survey method. Soil sample taken according to point observation based on 3 criteria that have been made before, such as never flood, affected river water flooding, and affected sea water flood. Determination sample *purposive random* sampling that all samples were 9 points. Undisturbed sampling using a ring and disturbed sample using drill with 3 points around depth was 1-2 meters and composited as much as 1-2 kg.

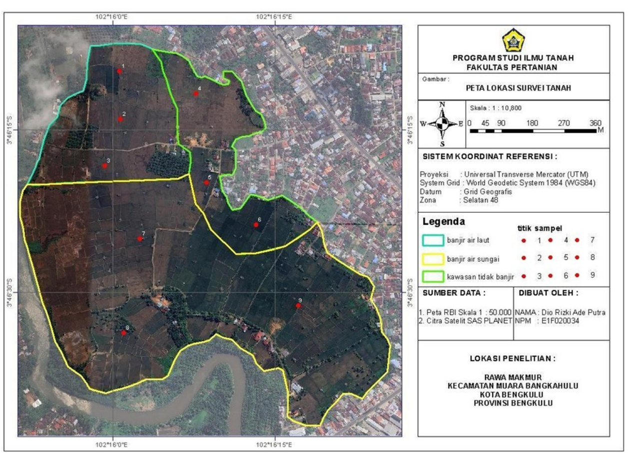

Figure 1. Map of the research area

Analysis soil in the laboratory

Analysis of soil texture used Hydrometer method, Volume weight used ring method, Specific gravity used Pycnometer method, pH KCL used pH meter method, C- organic use Walkey and Black method, N-total using Kjeldahl, P- available used P-bray, K-dd used Extraction of ammonium acetate pH 7 (NH_4OAC pH 7), Na used Extraction of ammonium acetate pH 7 (NH_4OAC pH 7), KTK used Extraction of ammonium acetate pH 7 (NH_4OAC pH 7). Then based data processing instruction technical Evaluation Soil Fertility from Bogor Soil Research (1995).

Table 1. Criteria of soil chemical properties according to instruction technical evaluation soil fertility from Bogor Soil Research (1995)

No	Chemical Properties	Mark	Criteria
1	CEC (me 100 g^{-1})	> 40	Verry High (ST)
		25-40	Height (T)
		17-24	Medium (S)
		5-16	Low (R)
		<5	Very Low (SR)
2	C- organic (%)	>5.00	Very High (ST)
		3.01-5.00	Height (T)
		2.01-3.00	Medium (S)
		1.00-2.00	Low (R)
		<1.00	Very Low (SR)
3	P_2O_5 (mg 100 g^{-1})	>60	Very High (ST)
		41-60	Height (T)
		21-40	Medium (S)
		10-20	Low (R)
		<10	Very Low (SR)
4	K_2O (mg 100 g^{-1})	>60	Very High (ST)
		41-60	Height (T)
		21-40	Medium (S)
		10-20	Low (R)
		<10	Very Low (SR)
5	Saturation (%)	>70	Very High (ST)
		51- 70	Height (T)
		36-50	Medium (S)
		20-35	Low (R)
		<20	Very Low (SR)

Source : Evaluation Technical Instructions Soil Fertility from Bogor Soil Research (1995)

Determination of fertility status land based on instructions technical fertility soil of the Bogor Soil Research Center (PPT, 1995) which is presented in Table 2, then make fertility status map land in rice fields Ward Prosperous Swamp with 1:6,000 scale based on fertility parameters land that has been measured and fertility status land that has been obtained. Making fertility status maps of this land uses System Information Geographical with ArcGIS 10.3 software.

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

No	CEC	KB	P_2O_5, K_2O, C - organic	Fertility Status
1.	Q	Q	≥ 2 T without R	Tall
2.	Q	Q	≥ 2 T with R	Currently
3.	Q	Q	≥ 2 S without R	Tall
4.	Q	Q	≥ 2 S with R	Currently
5.	Q	Q	T > S > R	Currently
6.	Q	Q	≥ 2 R with T	Currently
7.	Q	Q	≥ 2 R with S	Low
8.	Q	S	≥2 T without R	Tall
9.	Q	S	≥2 T with R	Currently
10.	Q	S	≥2 S	Currently
11.	Q	S	Another combination	Low
12.	Q	R	≥2 T without R	Currently
13.	Q	R	≥2 T with R	Low
14.	Q	R	Another combination	Low
15.	S	Q	≥2 T without R	Currently
16.	S	Q	≥2 S without R	Currently
17.	S	Q	Another combination	Low
18.	S	S	≥2 T without R	Currently
19.	S	S	≥2 S without R	Currently
20.	S	S	Another combination	Low
21.	S	R	3 Q	Currently
22.	S	R	Another combination	Low
23.	R	Q	≥2 T without R	Currently
24.	R	Q	≥2 T with R	Low
25.	R	Q	≥2 S without R	Currently
26.	R	Q	Another combination	Low
27.	R	S	≥2 T without R	Currently
28.	R	S	Another combination	Low
29.	R	R	All combination	Low
30.	SR	T, S, R	All combination	Very low

Source: Evaluation Technical Instructions Soil Fertility from Bogor Soil Research (1995)

Note: ST = Very High; T = Height; S = Medium; R = Low; SR = Very Low

RESULTS AND DISCUSSION

Fertility land is a circumstance where land can support growth plants so you can produce good. Availability of nutrients contained within soil is very influential to level fertility land (Saosang *et al*., 2022). The results based on characteristic soil chemistry and criteria determination of fertility status based on PPT (1995) obtained class fertility land that is low are presented in Table 3 and explained through fertility status map land in Figure 2.

Table 3. Results of evaluation of soil fertility status of research locations

No	Sample	Parameter	Mark	Criteria	Fertility Status
1	SW 1	CEC (me 100 g-1)	31.08	Q	Low
		Saturation (%)	16.15	SR	
		P_2O_5 (mg 100 g-1)	4.03	SR	
		K_2O (mg 100 g-1)	0.25	SR	
		C- organic (%)	2.75	S	
2.	SW 2	CEC (me 100 g-1)	34.87	Q	Low
		Saturation (%)	23.86	R	
		P_2O_5 (mg 100 g-1)	3.93	SR	
		K_2O (mg 100 g-1)	0.25	SR	
		C- organic (%)	5.48	ST	
3.	SW 3	CEC (me 100 g-1)	35.60	Q	Low
		Saturation (%)	40.08	S	
		P_2O_5 (mg 100 g-1)	2.69	SR	
		K_2O (mg 100 g-1)	1.43	SR	
		C- organic (%)	5.12	ST	
4.	SW 4	CEC (me 100 g-1)	36.96	Q	Low
		Saturation (%)	13.28	SR	
		P_2O_5 (mg 100 g-1)	4.23	SR	
		K_2O (mg 100 g-1)	0.16	SR	
		C- organic (%)	3.72	Q	
5.	SW 5	CEC (me 100 g-1)	35.31	Q	Low
		Saturation (%)	14.67	SR	
		P_2O_5 (mg 100 g-1)	3.08	SR	
		K_2O (mg 100 g-1)	0.14	SR	
		C- organic (%)	3.86	Q	
6.	SW 6	CEC (me 100 g-1)	33.93	Q	Low
		Saturation (%)	11.49	SR	
		P_2O_5 (mg 100 g-1)	12,11	R	
		K_2O (mg 100 g-1)	0.21	SR	
		C- organic (%)	4.55	Q	
7.	SW 7	CEC (me 100 g-1)	39.83	Q	Low
		Saturation (%)	23.57	R	
		P_2O_5 (mg 100 g-1)	3.32	SR	
		K_2O (mg 100 g-1)	0.41	SR	
		C- organic (%)	5.97	ST	
8.	SW 8	CEC (me 100 g-1)	28.80	Q	Low
		Saturation (%)	23.99	R	
		P_2O_5 (mg 100 g-1)	3.41	SR	
		K_2O (mg 100 g-1)	0.46	SR	
		C- organic (%)	2.63	S	
9.	SW 9	CEC (me 100 g-1)	28.15	Q	Low
		Saturation (%)	20.31	R	
		P_2O_5 (mg 100 g-1)	4.16	SR	
		K_2O (mg 100 g-1)	0.26	SR	
		C- organic (%)	2.42	S	

Note : ST = Very High; T = Height; S = Medium; R = Low ; SR = Very Low

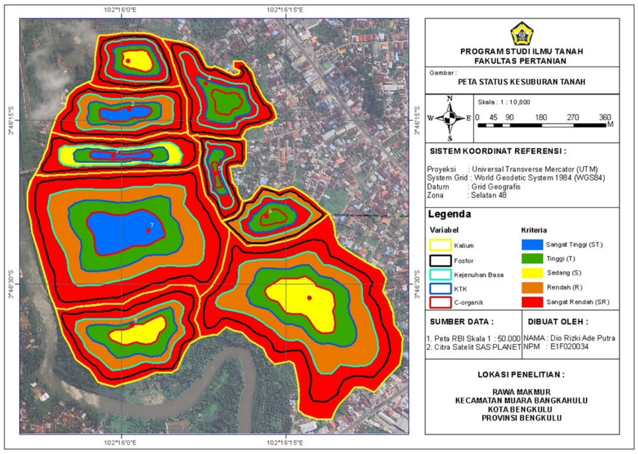

Figure 2. Map of soil fertility status in rice fields ward prosperous swamp

Cation Exchange Capacity (CEC)

From Table 3 and Figure 2 capacity cations are capable of absorbing and exchanging cations inside of soil. Result of measurement CEC value of land at the location observed based on criteria Bogor Soil Research (1995), CEC value of land from each point taking sample classified tall with mark ranges from 28.15 me 100 g^{-1} - 39.83 me 100 g^{-1}.

His height organic C- content as presented in Table 3, there is a location study that can influence CEC value. CEC is influenced by clay (Dala & Mutiara, 2019; Maro'ah *et al*., 2022). There are paddy fields texture dominant containing clay colloids of their own high ability in capacity cations (Prabowo & Subantoro, 2017). Results from Sumarniasih *et al.* (2021) also explained clay has its own stable high aggregate so that its own capacity exchange cations and capacity holding high water.

Saturation

From Table 3 and Figure 2 saturation base is a comparison between cations exchanged bases with capacity swap stated cations in percent. Saturation of base land that is not balanced can cause problems like too much acidic or base, which can hinder growth of plants. Saturation value based on research that is classified as very low until currently with marks ranges from 11.49% - 40.08%. Point samples that have very low criteria namely SW1 (16.15%), SW4 (13.28%), SW5 (14.67%), and SW 6 (11.49%), base saturation with criteria low namely SW 2 (23.86%), SW7 (23.57%), SW8 (23.99%), and SW9 (20.31%) and point samples that fall into the criteria currently namely SW3 (40.08%).

The low base saturation caused by flooding every year results in erosion so that content small talk in land decreases as well as the pH at the location study classified as very acidic with marks ranging from 3.68 – 4.39 as presented in Table 4. Base saturation is greatly influenced by the pH at the location study (Arief *et al*., 2022).

Table 4. Soil acidity level (soil pH)

No	Sample	pH	Criteria
1.	1	3.98	Very Sour
2.	2	3.71	Very Sour
3.	3	3.84	Very Sour
4.	4	3.75	Very Sour
5.	5	3.68	Very Sour
6.	6	3.96	Very Sour
7.	7	3.86	Very Sour
8.	8	3.87	Very Sour
9.	9	4.39	Very Sour

Soil organic C- levels

From Table 3 and Figure 2 results determine organic C- levels on site study from each point that is classified currently to very high with marks ranging from 2.42% - 5.97%. Point samples that have criteria currently namely SW1 (31.08%), SW8 (28.80%), and SW9 (28.15%) while criteria high namely SW4 (36.96%), SW5 (35.31%), and SW 6 (33.93%). Very high criteria namely SW2 (34.87%), SW3 (35.60%), and SW7 (39.83%).

Organic C- content is classified as criteria currently to show that many materials organic on-site study. C- organic is one of the determining parameters of fertility lands. C- organic value on site study classified currently to very high. This is influenced by habits of the farmer letting go residue plants in paddy fields (Peku Jawang, 2021). Furthermore, floods also bring rich sediment material organic as well as many plant dead rice consequence flooding also occurs source material organic later will decompose so increase organic C-content in paddy fields.

Content soil phosphorus

From Table 3 and Figure 2 it can be seen as the results of measurement content Phosphor on site observed research classified as very low until low with mark ranges from 2.69 mg 100 g^{-1}–12.11 mg 100 g^{-1}.

Very low criteria order to SW1 (4.03 mg 100 g^{-1}), SW2 (3.93 mg 100 g^{-1}), SW3 (2.69 mg 100 g^{-1}), SW4 (4.23 mg 100 g^{-1}), SW5 (3.08 mg 100 g^{-1}), SW7 (3.32 mg 100 g^{-1}), SW8 3.41 mg 100 g^{-1}), and SW9 (4.16 mg 100 g^{-1}) while low criterion is SW6 (12.11 mg 100 g^{-1}).

Availability of P in soil is greatly influenced by soil acidic. On location, pH ranges from 3.68 – 4.39 which is classified as very acidic as presented in Table 4. This caused formation phosphate from reaction P with aluminum and substances iron consequence from low pH causes plant difficult for absorb P so that reduce availability Phosphor (Morina *et al*., 2023). Soil at low pH cause content phosphorus inside to soil bound by Al and Fe (Kirnadi *et al*., 2022) forming Fe-P and Al-P so This compound is difficult late (Camila *et al*., 2023).

Soil potassium content

From Table 3 and Figure 2 it can be seen is known that potassium which is nutrients that are really needed by plants as one of the supporter growth and development plant. Potassium plays a role in add Power stand plant to disease as well as stimulate charging seed. Measurement results Soil potassium content at each point on-site samples observed research, classified very low criteria includes SW1 (0.25 mg 100 g^{-1}), SW 2 (0.25 mg 100 g^{-1}), SW 3 (1.43 mg 100 g^{-1}), SW 4 (0.16 mg 100 g^{-1}), SW 5 (0.14 mg 100 g^{-1}), SW 6 (0.21 mg 100 g^{-1}), SW 7 (0.41 mg 100 g^{-1}), SW 8 (0.46 mg 100 g^{-1}), SW9 (0, 26 mg 100 g^{-1}).

The low potassium value at the location caused by flooding that resulted annual paddy fields are flooded in long time. Moreover, it's a habit farmer who don't or only give fertilizer in amount a little is also one reason low potassium at the location study. The ion of Potassium belongs to easy move and easy for loose. It's flooded land rice fields because flood resulted percolation so that dissolve K in land (Sari *et al*., 2022) through the washing process (Gunawan *et al*., 2019) and erosion land (Al Mu'min *et al*., 2016).

CONCLUSION

The analysis of soil samples revealed significant variations in key fertility parameters across the study area. The Cation Exchange Capacity (CEC) ranged from 28.15 me 100 g^{-1} to 39.83 me 100 g^{-1}, indicating a high level of cation retention capacity in the soil. Conversely, base saturation levels were consistently classified as very low, ranging from 11.49% to 40.08%, suggesting a deficiency in exchangeable base cations. Organic carbon content ranged from 2.42% to 5.97%, indicating varying degrees of soil organic matter accumulation, with some areas exhibiting very high levels. Phosphorus content was found to be very low, with concentrations ranging from 2.69 mg 100 g^{-1} to 12.11 mg 100 g^{-1}. Similarly, soil potassium content was uniformly classified as very low, with values ranging from 0.14 mg 100 g^{-1} to 1.43 mg 100 g^{-1}. These findings underscore the critical impact of flooding on soil fertility. The observed low fertility status of the soil in the study area highlights the need for targeted interventions to improve soil health and agricultural productivity. Specifically, addressing deficiencies in phosphorus, potassium, and pH levels is imperative for enhancing soil fertility. In conclusion, the research demonstrates the importance of mitigating the adverse effects of flooding on soil fertility. Implementing strategies such as the application of phosphorus and potassium fertilizers can help replenish essential nutrients and enhance the overall fertility status of the soil in the Village of prosperous swamp.

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