

INVESTIGATION ON CHARACTERISTIC OF WATER AND SOIL QUALITY AT IRRIGATION AREA ON PEAT SOIL IN INDONESIA

Saga University Student Member ○ Siti Rizkyna Noorsaly

Saga University Regular Member MISHIMA Yuichiro

Lambung Mangkurat University Non-Member Maya Amalia Achyadi

1. INTRODUCTION

Water quality has a significant impact on the paddy fields' capacity to produce rice. Low productivity of paddy field is a result of low soil fertility, high iron concentration, high soil acidity contained in peat soil and inadequate irrigation system performance (M. Anda, 2008, Koesrini, 2018). In Indonesia, tidal swamp land is commonly used for agriculture, which the irrigation system is highly dependent on tidal fluctuations. However, tidal swamp habitat is the most common location for acid sulfate soil (Nugroho, 1993). Figure 1 shows the investigation location in this study. Danda Besar Swamp Irrigation Area (SIA) is one of agricultural field where irrigation system dependent on the tidal fluctuation of Barito River. Danda Besar SIA is located 54 km from estuary of Barito River, extending inward about 7 km along primary channel, and difference between high tide and low tide is 80-100 cm. Danda Besar SIA has approximately 2,200 hectares of potential swamp land. The Danda Besar tidal swamp still has poor productivity. In this region, the annual planting yield for rice was only 2 t/ha. (DCC Consultant 2007). Water quality in this region indicates high acidity phenomena that is result of high Iron (Fe) concentration and low pH recorded in all water sources. Pyrite oxidation may occur in acid peat soil contribute to low pH phenomena. Current method to solve this problem is using alkaline source such as lime or calcium hydroxide ($\text{Ca}(\text{OH})_2$) have been suggested (Noorsaly et al, 2022). However, amount of alkaline required to neutralize irrigation area effectively has not been systematically studied yet. The objective of this study was to present irrigation water quality parameter at low tide and high tide condition and provide information about mass of alkaline source required for neutralization in specific unit (kg/m^2).

2. METHODOLOGY

2.1 Water sampling based on tidal change

Observation of tidal level change was conducted by using water level sensor. Ultrasonic wave sensor was put in the secondary channel for 24 hours. After obtained result of highest tidal level and lowest tidal level, water sampling in each condition was carried out. To represent the water quality in irrigation system, water sample was taken in the primary channel, secondary channel, and tertiary channel.

2.2 Acidity measurement

Soil sample above 10 cm from surface of each channel and paddy field was taken to measure acidity. Soil samples were washed by deionized water and filtered through membrane filter ($0.45 \mu\text{m}$ pore size). (Kanbara, S et al 2010).

Each filtered water was analyzed by titrating sodium hydroxide (NaOH) solution to a pH 7-8. Mass of alkaline will be calculated with other terms by the following equation.

$$M_{alkaline} = \left(\frac{\text{Vol. NaOH} \times \text{conct. NaOH}}{M_{dry soil}} \right) \times \left(\frac{\text{molar mass of CaOH}^2}{2} \right) \quad (1)$$

Density of soil also measured to obtained mass of dry soil in specific area. We took soil sample in paddy field around 15 cm depth considering growth of root. The final unit mass of alkaline per m^2 obtained by following equation:

$$M_{alkaline}/\text{m}^2 = M_{alkaline} \times M_{dry soil}/A \quad (2)$$

3. RESULT AND DISCUSSION

Tidal swamp irrigation type as in Danda Besar area doesn't have any other control for water management supply in irrigation system instead of relying on tidal fluctuation. As the initial step, to understand mechanism of low pH phenomena in this irrigation system we obtained water properties at each rising water level and decreasing water level condition. Firstly, we observed tidal level change for 24 hours in secondary channel as shown in

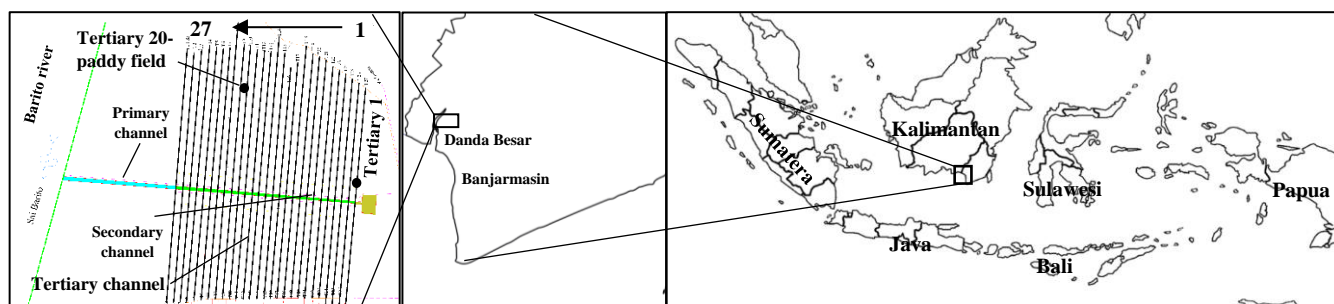


Figure 1. Investigation location

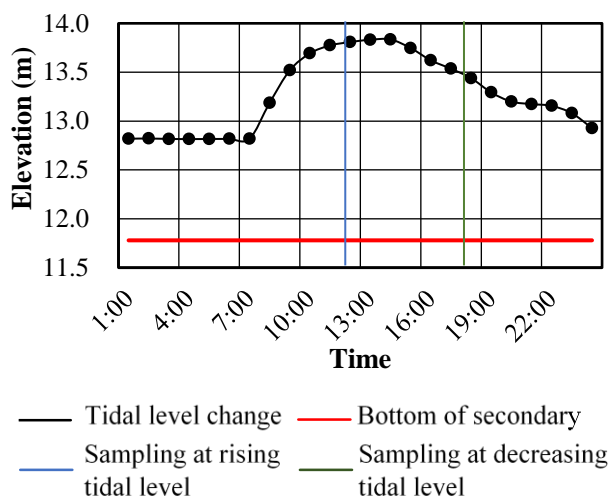


Figure 2. Tidal level change for 24 hours

Figure 2. Lowest tidal level change was occurred at around 01.00 and highest at around 13.00, with difference of water level around 100 cm. Therefore, as presented in Table 1 water sampling was carried out at each condition and discovered that water properties such as acidity was lower at the high tide condition contributed to increasing pH instead of at low tide condition. We indicated this happen due to acidity in water was diluted when high tidal came in from Barito River.

According to tidal level change result in Figure 2, implied that there was several hours water stayed at same level in the irrigation system from 01:00 to 06:00 which was the sign of water didn't circulate properly, this may happen due to sedimentation that deposited at some points in irrigation channel. Since water from Barito River invited into inside of irrigation system only depend on natural high tide without any pump or gate to control the water, therefore sedimentation at bottom of channel became major obstacle of water circulation. Exchanging water of Barito River and water from paddy field was the role of irrigation system as medium to leach acidity and other toxic material. Acidity leaching tends to not perform well as result of water stagnant on specific time.

In this paper, alkaline mass per m^2 was calculated at some representative points in irrigation area. The result shows in the Table 2, connection point between tertiary 20 and paddy field was the location where required highest alkaline mass/ m^2 among other location. Peat soil that contains high organic content or pyrite in bottom of channel may release its acidic to water in channel and may be source of acidity in the irrigation system. Highest acidity concentration was found in paddy field may be the result of less exchangeable water stayed most of the time in paddy field. However, further research considering more detail approach should be conducted to clarify mechanism of high acidity and improving sustainable water environment parameters in this study area.

Table 1. Water quality at high and low tide

No	Item	Unit	Rising water level			Decreasing water level		
			P	S	T	P	S	T
1	pH	-	4.89	4.97	5.08	3.93	2.56	2.44
2	Acidity	mmol/g-dry	4.40	4.29	6.51	4.55	4.03	3.76

P = primary channel, S = secondary channel, T = tertiary channel

Table 2. average mass of alkaline per m^2

No	Location	M Alk (gr/kg-dry)	M dry/A (kg-dry/ m^2)	Kg Ca(OH) ₂ / m^2
1	River-primary	178.648	90.20	16.12
2	Secondary	152.548	143.38	21.87
3	Tertiary 20-paddy field	216.270	160.28	34.66
4	Paddy field	161.512	174.13	28.12
5	Tertiary 1	141.862	136.78	19.40

4. CONCLUSION

1. Water quality at rising tidal level was higher rather than at decreasing tidal level, indicated that acidity was diluted when high tide came in from Barito River.
2. Water stagnant for several hours recorded in irrigation channel may happened as result of sedimentation at bottom of channel that contributed to acidity leaching tend to not perform completely.
3. Paddy field area and connection point between tertiary 20 and paddy field were the location require highest alkaline source for neutralization.
4. Further research considering detail approach should be conducted to clarify situation in this area.

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