Identification of quality of irrigation water Danda Besar Swamp Irrigation Area in Barito Kuala District, South Kalimantan, Indonesia

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Identification of quality of irrigation water Danda Besar Swamp Irrigation Area in Barito Kuala District, South Kalimantan, Indonesia

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Abstract. Danda Besar Swamp Irrigation Area (SIA) is located in Danda Jaya Village in Rantau Badauh District, Barito Kuala Regency, South Kalimantan Province, Indonesia. It is one of tidal swamp reclamation where tidal fluctuation of Barito River affects to the hydrological condition. Danda Besar SIA has potential agricultural land about 2,200 ha, and the productivity of paddy field was only 2 ton/ha in average for each time planting year. Two ton/ha is too low productivity due to problem of water quality in irrigation canal. However, fundamental information for the management of water quality of irrigation, monitoring data of water quality, is not measured yet. This fundamental research was conducted to identify and analyze condition of irrigation water quality. The field survey was carried out in dry months, May and June 2021 at primary canal, secondary canal, tertiary canal and pond. The final result for 6 parameters of the 4 locations (primary canal, secondary canal, tertiary canal and pond) showed there were 3 parameters (TDS, DO, and Sulfate (SO_4^{2-})) fulfill the class II standard, meanwhile there were 3 parameters (pH, Iron (Fe) and BOD) not fulfill the class II standard according to Government Regulation No. 22 year 2021 regarding Implementation of Environmental Protection and Management. The high content of Iron (Fe) and low content of pH recorded in all water sources should be addressed with urgency since this phenomenon as a result of pyrite oxidation affect to pH condition and may cause the low productivity of paddy field.

Keywords: Swamp Irrigation, water irrigation quality properties, low pH, Danda Besar

1. Introduction

1.1 Study Area

In Indonesia, swamp area spread throughout the country. There are around 33.4 million ha of swamp area in more than 17 provinces [1]. Which spread in Sumatera Island ± 12.93 million ha, Java Island ± 0.90 million ha, Kalimantan Island ±10.02 million ha, Sulawesi Island ± 1.05 million ha, Maluku Island and North Maluku Island ± 0.16 million ha, and Papua Island ± 9.87 million ha [2].

Java Island is an island with the biggest population in Indonesia, about 60% of the 225 million Indonesia population. Hence, Java Island become the center of national rice supply, but there are a lot of rice fields has been changed to be industrial areas and road construction. Consequently, Indonesia government tried to find other potential locations for rice field cultivation. Government expects swamp land can be utilized optimally to be productive rice field due to increasing demand for sustainable food production [3]

In Kalimantan Island especially, there are 1,052,208 ha of reclaimed swamp tidal area, and only 491,845 ha already utilized for paddy field, farm, pond, etc. [4]. Until now, the utilization of tidal swamp land is not optimal and the average rice production is only 1-2 tons/ha. This is due to low soil fertility, high soil acidity, high iron content, and also the water system network does not exist or has not been operated properly [5].

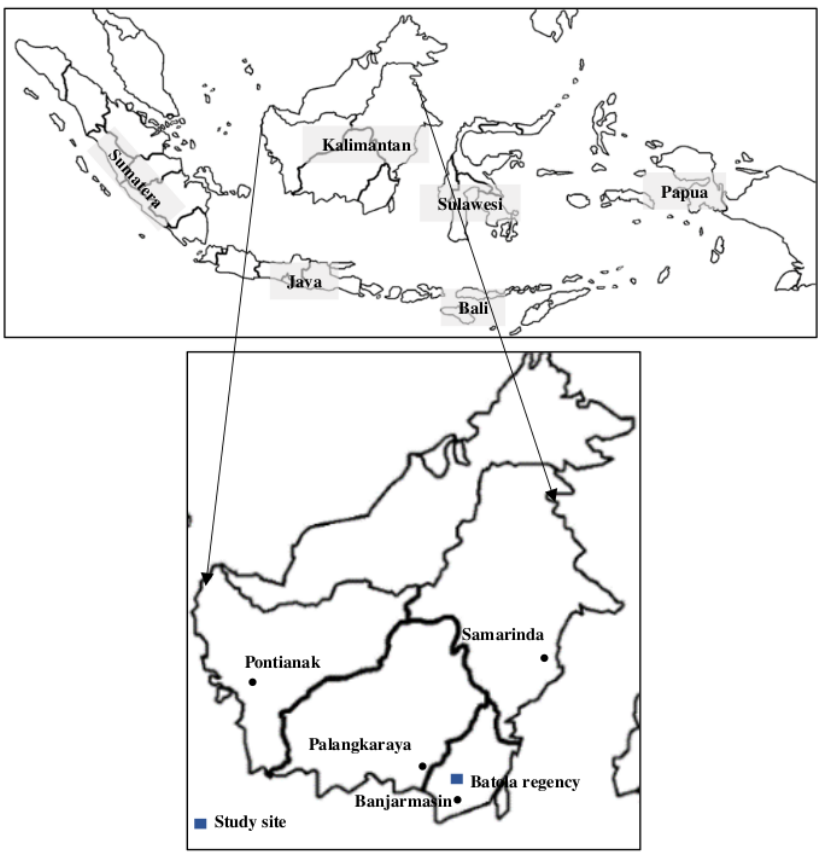

Figure 1. Location of study area [6]

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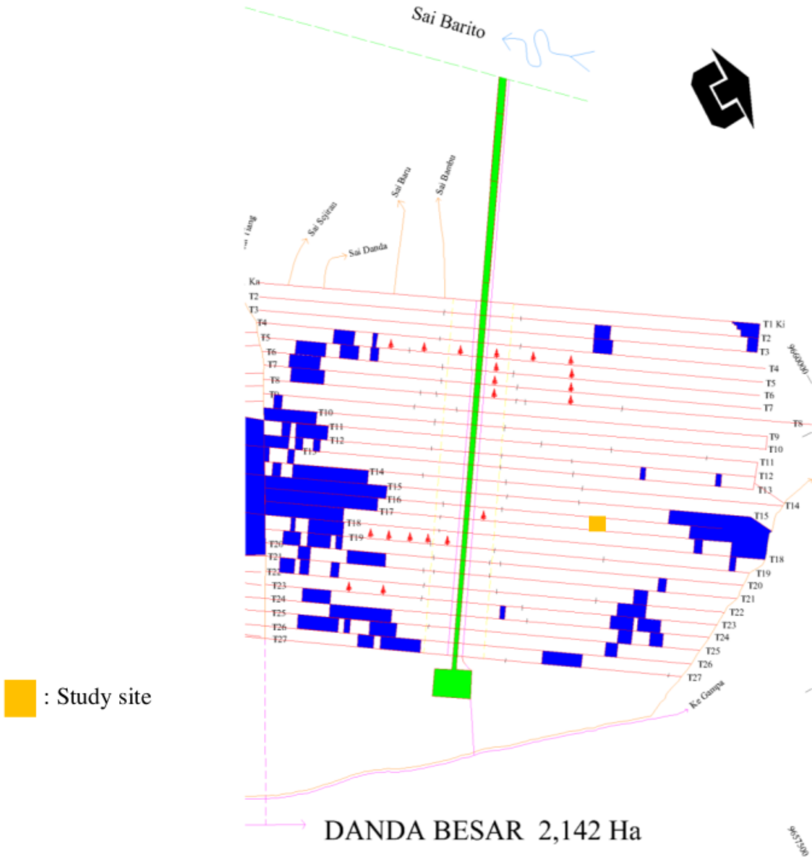

Figure 2. Danda Besar Swamp Irrigation Area [7]

The location of study area is given in Figure 1. Danda Besar Swamp reclamation network is one of tidal swamp reclamation where tidal fluctuation of Barito River affects to the hydrological condition. Administratively, Danda Besar Swamp Irrigation Area (SIA) included in Danda Jaya Village in Rantau Badauh District, Barito Kuala Regency, South Kalimantan Province. Danda Besar SIA has potential swamp land about 2,200 ha. Productivity of tidal swamp in Danda Besar is still low. Average rice production in this area was only 2 ton/ha with one time planting a year [7].

This fundamental research was conducted to identify and analyze conditions of irrigation water quality.

1.2 Water Quality

Swamp land areas consist mostly of acid sulphate soils, which have problem such as waterlogging, tidal flooding, low bearing capacity and presence of pyrite [8]. Acidity in acid sulphate soil is often produces by the oxidation of pyrite buried in deeper layers of soil [9]. Under reductive conditions, pyrite can result in high solubility of toxic substances such as Fe^{2+}, H_2S, CO_2 and other organic acid contents. Pyrite concentration control is the most important in the irrigation tidal water management system. High concentration of Al and Fe are main problem in the rice field production not only tropical area, but also sub-tropical area. Approximately, about 4 million ha rice field in the world influenced by Al and Fe toxicity, decreasing rice production up to 30-60% and crop failure is the worst [10]. Farmers have traditionally applied lime or other chemical neutralizers such as rock phosphate to reduce soil acidity, which has proven to be effective and practical [11].

The study by Imanudin et al [12] result that to overcome water quality problem in a tidal swamp land where acidity is considerably high, can be solved by applying passive technology through improvement of biological process at the canal bed and the water surface. To increase water pH and decreasing Fe, ameliorant substances used such as phytoremediation by planting water hyacinth on surface of water, conblock construction at the canal base using mixture of sand-cement-lime-rice-straw ash with volume ratio of (2:2:1:3) showed significant effect in increasing pH of water.

Low phosphorus (P) availability and high Fe concentration are the dominant characteristic of acid sulphate soils in swamp land area. To obtain favourable for rice production, optimum agricultural management practices are required to leach the excess of Fe^{2+} and to prevent or minimize loss of P from soil. The experiment conducted by using rice straw on leaching of Fe and loss of P in an acid sulphate soil. The results showed that RS application was effective in preventing P loss from the soil at 6 weeks after planting (WAP) and decreased the pH of leachate [13].

2 Methodology

2.1 Water sampling

This research was carried out from May to June 2021 during dry season (according to Oldeman Climate Classification) which the monthly rainfall was under 100 mm/month. Water samples were collected from 4 areas, primary canal, secondary canal, tertiary canal and pond in Danda Besar SIA as presented in Figure 2. Five litter of water sample of each areas obtained to measure 6 parameters, those are TDS (Total Dissolved Solid), DO (Dissolved Oxygen), Sulfate (SO_4^{2-}) concentration, Iron (Fe) concentration, pH level, and BOD (Biological Oxygen Demand). The water quality testing method and reference is written in Table 1. Water samples were analysed in Laboratory of Environmental Research Center in Lambung Mangkurat University.

Table 1. Water quality testing method

Parameter	Testing method	Reference
TDS	Conductometric	
DO	Iodometric (Azide Modification)	INS (Indonesian National Standard) 06.6989.14.2004
Sulphate	Turbidimetric	INS (Indonesian National Standard) 06.6989.20.2004
Fe	Atomic Absorption Spectroscopy	INS (Indonesian National Standard) 06.6989.4.2009
pH	pH meter	INS (Indonesian National Standard) 06.6989.11.2004
BOD	Titrimetric	INS (Indonesian National Standard) 06. 6989.72.2009

2.2 Water quality standard and classification

In this research, water samples were measured using physical-chemical and biological parameters for quality standard according to Indonesia Government Regulation No. 22 year 2021 [14]. Determination of water quality classification based on the allocation is given in Table 2 and parameter range for each class is given in Table 3.

Table 2. Water quality classification

Class	Allocation
Class I	Drinking water
Class II	Water recreation, freshwater fish farming, livestock, and agriculture
Class III	Freshwater fish farming, livestock, and agriculture
Class IV	Agriculture

Table 3. Water quality standard

No	Parameter	Unit	Class I	Class II	Class III	Class IV	Remarks
1	TDS	mg/L	1000	1000	1000	2000	not applicable for estuary
2	DO	mg/L	6	4	3	1	minimum requirement
3	Sulphate	mg/L	300	300	300	400	
4	pH		6-9	6-9	6-9	6-9	not applicable for peat water (based on natural condition)
5	Iron (Fe)	mg/L	0.3	-	-	-	
6	BOD	mg/L	2	3	6	12	

3 Result and discussion

3.1 Water quality characterization

3.1.1 pH

The pH value in Danda Besar SIA recorded in range 4.89 to 5.16 based on Figure 3. All of the values are not acceptable within the threshold of Government Regulation no.22/2021 value of 6-9. The pH value indicate how acidic or basic water is. The pH value = 7 is being neutral and pH less than 7 indicate acidity, meanwhile pH more than 7 indicate base. During dry season ground water level decrease below pyrite position within soil, and pyrite that are exposed to air will be oxidated. Pyrite oxidation release some toxic acid substances; thus, it lowers the pH value. According to [3] explained that pH value may decline to 3 in every pyritic horizon that are exposed to air, which is the pH value of 3 is extremely low.

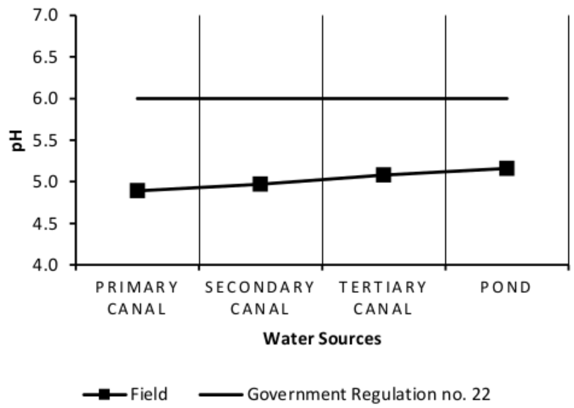

Figure 3. The pH value of Danda Besar SIA in dry season

3.1.2 DO (Dissolved Oxygen)

Dissolved oxygen parameter denotes the amount of oxygen present in water. Dissolved oxygen in water plays a very important role in the process of absorption of food by organism in the water. Commonly, DO in channel of agriculture field tends to be higher due to photosynthesis by algae. Considering Indonesia is tropical country, there are a lot of solar energy and water is suitable for cultivation of algae. According to Ferdinandiaz et al [15] algae grow properly in DO concentration more than 2 mg/L. However, Pratiwi et al [16] confirmed that a good dissolved oxygen concentration above 6.3 mg/L. High oxygen levels describe good and unpolluted water quality, otherwise low implies poor and polluted water quality. Decreasing DO levels may be caused by domestic and industrial waste entering the waters [17]. According to Figure 4, the DO value of Danda Besar SIA in dry season ranges from 4.7 to 4.8 mg/L. This value is suitable for class II, III and IV water designation according to Government Regulation No. 22/2021 which is water can be utilized to irrigate corps due to dissolve oxygen content of 4.7 – 4.8 still adequate for growth of organism.

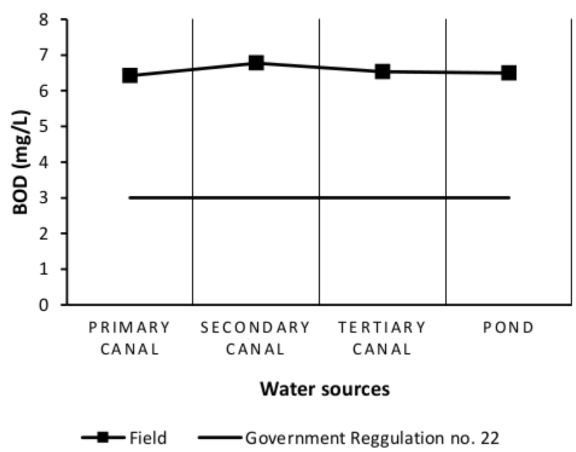

Figure 4. The DO value of Danda Besar SIA in dry season

3.1.3 TDS (Total Dissolved Solid)

Total dissolved solid (TDS) is a term used to describe the organic matter present in solution in water. As presented in Figure 5, TDS value range from 155 to 950 mg/L in all areas. This value indicates that TDS in dry season is still accordance with the required quality standards Government Regulation No.22/2021 which are still below 1,000-2,000 mg/L. The TDS value showed that in tertiary canal and pond were found quite much amount of organic matter. This phenomenon probably caused by strong water stagnant in the irrigation water due to irrigation system that unreliable. According to Salmani et al [18] TDS concentration is strongly influenced by water flow. Waste disposed from industrial activities affects the TDS value [19].

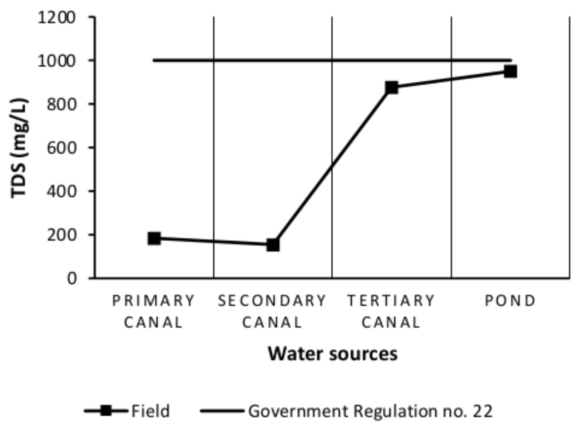

Figure 5. The TDS value of Danda Besar SIA in dry season

3.1.4 BOD (Biological Oxygen Demand)

The BOD value of Danda Besar SIA in dry season are relatively high in all areas, highest level of BOD is in secondary canal 6.77 mg/L and the lowest is in primary canal 6.42 mg/L based on Figure 6. This value only suitable for class III water designation which is water can be utilized to irrigate corps according to Government Regulation No. 22/2021. BOD implies the amount of dissolved oxygen needed by microorganisms to decompose or decompose organic matter under aerobic conditions [20]. Considering with the result of pH, BOD was evaluated underestimated due to prevention of biochemical reaction by low pH.

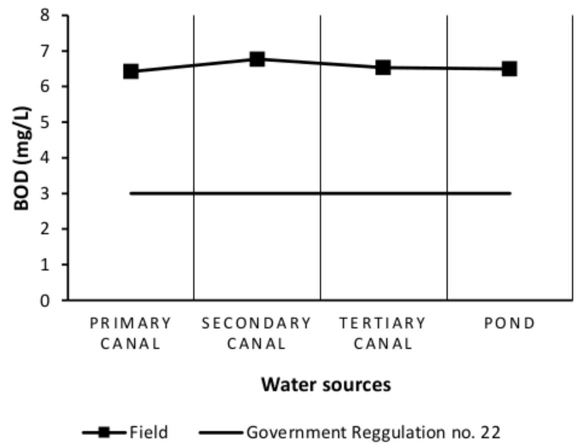

Figure 6. The BOD value of Danda Besar SIA in dry season

3.1.5 Iron (Fe)

As presented in Figure 7, concentration of Iron (Fe) recorded in the water sources sample ranged between 0.122 and 0.142 mg/L. All of the values are not acceptable within the threshold of Government Regulation no. 22/2021 value of 0 mg/L for the class II, III and IV. High concentration of Fe could be a problem to vegetable production, and in excess could compete with other nutrients like phosphorus [21]. Oxidation of pyrite generates sulfuric acid that dissociate to release H^+ in the water and responsible for the steep drop of pH. According to Zeng et al [22] reaction of decreasing pH is related to dissolution and precipitation of Pyrite, which component is Iron and hydrogen sulphide. Hence, higher concentration of Iron (Fe) is lower concentration of pH. Meanwhile in this investigation, this result can not indicate relationship between concentration and pH clearly.

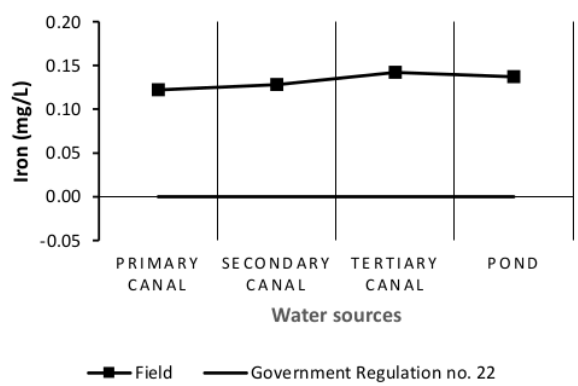

Figure 7. The Iron (Fe) value of Danda Besar SIA in dry season

3.1.6 *Sulphate (SO_4^{2-})*

Concentration of SO_4^{2-} recorded quite constant in all water sources sample ranged between 21.3 to 22.9 mg/L based on Figure 8. Observation of SO_4^{2-} content in Danda Besar SIA during dry season is still in accordance with Government Regulation No. 22/2021, which are still below 300 mg/L. Due to oxidation of pyrite, the organic acid from peat and acid sulfate soil might have reacted with organic matter as well as soil mineral and release Fe^{2+}, SO_4^{2-}, and H^+, remarkably in tropical areas where conditions were favorable for weathering.

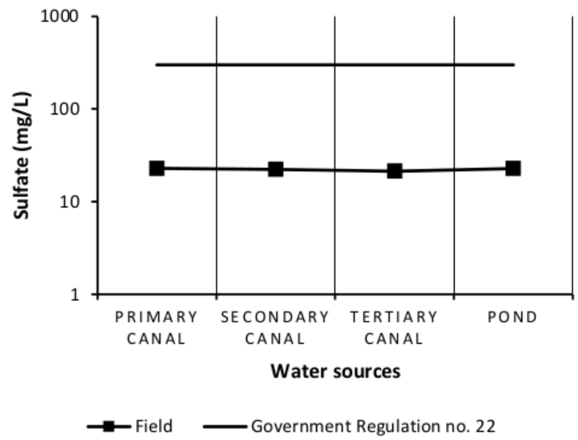

Figure 8. The SO_4^{2-} value of Danda Besar SIA in dry season

4 Conclusion

The current study was conducted in Danda Besar SIA to identify and analyzed water quality condition. The values of TDS, DO, and Sulphate (SO_4^{2-}) were within the threshold of class II water classification according to Government Regulation of Indonesia No. 22/2021. Meanwhile, the value of BOD was only suitable for class III which is water can be utilized to irrigate corps. The high content of Iron (Fe) and low content of pH recorded in all water sources should be addressed with urgency since these phenomena were pointed out that Fe contained in soil of paddy field as a result of pyrite oxidation affect to pH condition and may cause the low productivity of paddy field. A method to solve this problem using alkaline source like lime or calcium hydroxide (Ca $(OH)_2$) have been suggested. However, it is not discussed yet based on material balance. Therefore, behavior of ion in soil and water has to be clarified to grasp material balance of iron. Overall, the further research should be carried out to enhance paddy field production by improving quality of water irrigation.

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