

# THESIS

**Inhibition of Pyrite Oxidation BY ORGANIC MATERIALS  
IN VARIOUS GROUNDWATER CONDITIONS**

***INHIBITION OF PYRITE OXIDATION BY ORGANIC  
MATTER UNDER VARIOUS SOIL WATER  
CONDITIONS***



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2021**

## **SUMMARY**

**TRIOVANI DIAMOND. Inhibition of Pyrite Oxidation by Organic Matter Under Various Soil Water Conditions. (Supervised by MARSland SABARUDDIN).**

Pyrite oxidation occurs when pyrite is in contact with oxidizing agents, namely oxygen ( $O_2$ ),  $Fe^{3+}$ , and oxidizing organisms that can increase soil acidity and increase the solubility of Al and Fe in the soil. The rate of pyrite oxidation can be suppressed by the addition of ameliorant and water level control. This study aims to study the effect of organic matter and soil moisture conditions on the inhibition of pyrite oxidation. This research was conducted in the greenhouse of the Department of Soil, Faculty of Agriculture, Sriwijaya University according to a completely randomized factorial design with two factors, the dose of organic matter and water conditions. The results showed that the treatment with organic matter and maintained water conditions ( $B_1K_1$ ) was the best treatment in maintaining soil pH, dissolved Fe and dissolved Sulfate and preventing pyrite oxidation.

*Keywords : Pyrite Oxidation, Organic Matter, Water Condition.*

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*Key words : Pyrite Oxidation, Organic Matter, Water Condition.*

# THESIS

## Inhibition of Pyrite Oxidation BY ORGANIC MATERIALS IN VARIOUS GROUNDWATER CONDITIONS

As One of the Requirements to Get a Bachelor's Degree in Agriculture  
at the Faculty of Agriculture, Sriwijaya University



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2021

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**PENGHAMBATAN OKSIDASI PIRIT OLEH BAHAN  
ORGANIK PADA BERBAGAI KONDISI AIR TANAH**

**SKRIPSI**


Sebagai Syarat untuk Mendapatkan Gelar Sarjana Pertanian  
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Menyatakan bahwa semua data dan informasi yang dimuat di dalam skripsi ini merupakan hasil kegiatan saya sendiri dibawah supervisi pembimbing, kecuali yang dicantumkan dengan jelas sumbernya. Apabila dikemudian hari ditemukan adanya unsur plagiasi dalam skripsi ini, maka saya bersedia menerima sanksi akademik berupa pencabutan gelar dari Universitas Sriwijaya.

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Indralaya, November 2021



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## **BIOGRAPHY**

The full name of the author is Berlianti Triovani, commonly called Berlianti. The author is the third of four children, from the couple Mr. Jumari SH and Mrs. Dra. Herawati. The author was born in Pagaralam City on November 12, 1999. The author's address is Jl. R. Soeprapto No. 61 Tanjung Agung Village, South Pagaralam District, Pagaralam City, South Sumatra. Prior to his undergraduate education at Sriwijaya University, the author studied at Aisyah Kauman Kindergarten in Pagaralam City in 2005 and continued to elementary school at Muhammadiyah 1 Elementary School in Pagaralam. After that, the author continued his junior high school education at SMP Negeri 1 Pagaralam. In 2014 the author entered high school, namely SMA Negeri 1 Pagaralam and graduated in 2017.

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## **FOREWORD**

Praise and gratitude the author goes to the presence of Allah SWT, God Almighty, who has bestowed His grace and guidance to the author so that the author can complete the writing of the thesis entitled "Inhibition of Pyrite Oxidation by Organic Materials in Various Groundwater Conditions".

This thesis was prepared as a requirement to obtain a Bachelor's degree in Agriculture at the Faculty of Agriculture, Sriwijaya University. In this opportunity, the author also expresses his gratitude to Mr. Ir. Marsi, M.Sc., Ph.D and Mr. Ir. Sabaruddin, M.Sc., Ph.D as thesis supervisor and Dr. Ir. Agus Hermawan, MT and Mr. Dr. Ir. Adipati Napoleon, MP as the examiner lecturer who has provided guidance, direction, and thoughts in writing this thesis. The author also expresses his gratitude to his parents, brothers and sisters who always provide support and prayers. I also don't forget to thank my friends in Soil Science 2017, my research team colleagues, as well as all parties involved and helping in the research process up to the writing of this thesis.

In the preparation of this thesis, the author is fully aware that this thesis is still far from perfect because of the limited experience and knowledge of the author. Therefore, the writer expects criticism and suggestions from all parties for a better thesis in the future.

Indralaya, November 2021

**Writer**

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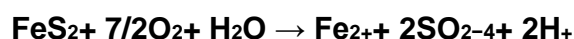
CHAPTER 1  
**PRELIMINARY**

### 1.1. Background

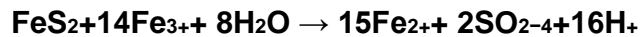
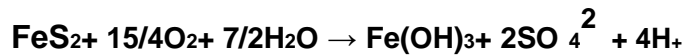
Swamp land is land that is spread over several areas in Indonesia and can be managed into potential land for sustainable agriculture. Swamp land is divided into lowland swamps and tidal swamps. Tidal marshes have the characteristic that in the soil layer there is a layer of sulfidic or pyrite material and is often also referred to as acid sulfate soil (Ratmini, 2018). Acid sulphate soil consists of potential acid sulphate soil and actual acid sulphate soil. Potential acid sulfate soils generally have a pyrite layer at a depth of more than 50 cm from the soil surface, while in acid sulfate soils the actual pyrite layer is located at a depth of less than 50 cm from the soil surface (Razie, 2019). The pyrite layer is formed as a result of the deposition of mineral and organic materials originating from higher elevations which are affected by tides.

Pyrite oxidation occurs when the pyrite layer is exposed to oxygen caused by lowering of ground water level or drought. The decrease in groundwater level can cause cracks on the soil surface caused by drought, root marks or excessive drainage so that oxygen can enter the soil and can result in the oxidation of the pyrite layer (Harahap, 2014). Pyrite oxidation can further increase the solubility of Al and Fe (Razieet *al.*, 2013). The oxidation of pyrite caused by oxygen as an oxidizing agent is less dangerous when compared to the oxidation caused by Fe<sup>3+</sup>. This is in accordance with the pyrite oxidation reaction where oxidation caused by oxygen only produces 2 moles of H<sup>+</sup> ions, while the pyrite oxidation caused by Fe<sup>3+</sup>

produces 16 moles of H<sup>+</sup> ions. The following is the oxidation reaction of pyrite:







Based on the above reaction the presence of  $\text{H}^+$  ions bonded with sulfate will become a strong acid capable of releasing  $\text{Al}^{3+}$  from aluminosilicate minerals and can result in a decrease in the pH value of the soil and make the soil very acidic, namely  $<4$ , which causes the Al solubility level to be higher, besides the Fe contained in pyrite will change shape and will be toxic to plants (Susanto *et al.*, 2014; Soewandita, 2018; and sustainable *et al.*, 2016). In soil that has undergone pyrite oxidation, pale yellow jarosite rust will be found in the cross section of the soil and is often referred to as pyrite *clay painter* in puddles of water that are toxic (Sustiyah *et al.*, 2011).

Pyrite oxidation occurs when pyrite is in contact with an oxidizing agent, namely oxygen ( $\text{O}_2$ ),  $\text{Fe}^{3+}$ , and oxidizing organisms that can accelerate the pyrite oxidation process. The rate of pyrite oxidation can be suppressed by adding ameliorant and controlling groundwater levels. One of the ameliorant ingredients that can be added is organic matter. In swamps, organic matter functions to maintain a reductive atmosphere and can chelate metals such as  $\text{Fe}^{3+}$  (Annisa and Subagio, 2016). Setiawati's Research *et al.* (2019), showed that the addition of organic matter (4, 8, 12, 16, and 20 tons/ha) and incubation time of 30 days can suppress the occurrence of pyrite oxidation and increase soil pH from 3.73 to 5.38. The addition of organic matter can suppress the occurrence of pyrite oxidation caused by  $\text{Fe}^{3+}$  ions by reducing the rate of  $\text{Fe}^{3+}$  production in the  $\text{Fe}^{3+}$  reduction process to  $\text{Fe}^{2+}$  and increase oxygen consumption by decomposer microorganisms, and can cover the pyrite layer so that it does not come into direct contact with oxygen (Fahmi and Ratmini, 2017). Pyrite oxidation control can also be done by reducing the supply of oxygen to the soil. The supply of oxygen in the soil can be suppressed by adjusting the groundwater level. Low availability of oxygen will suppress the population of iron-oxidizing bacteria (Neira *et al.*, 2015).

Based on the description above, practical and theoretical pyrite oxidation can only be inhibited by stopping or reducing the oxygen supply to the

in the ground. This can be done by adjusting the water level above the pyrite layer or covering it. On the other hand, if the pyrite oxidation is caused by  $Fe^{3+}$  ions it can be suppressed the rate of  $Fe^{2+}$  ion production by giving ameliorant which has the ability to complex  $Fe^{3+}$  ions. Therefore, research on the inhibition of pyrite oxidation by using ameliorant in the form of organic matter and in various groundwater conditions was carried out.

#### 1.2. Formulation of the problem

1. Can the application of organic matter inhibit the oxidation of pyrite?
2. Can the treatment by maintaining a 5 cm high puddle of water inhibit the oxidation of pyrite?
3. Can the combination of organic matter and groundwater conditions inhibit pyrite oxidation?

#### 1.3. Research purposes

This study aims to study the effect of organic matter and groundwater conditions on the inhibition of pyrite oxidation.

#### 1.4. Research Use

The purpose of this study was to obtain information about the potential of organic matter in inhibiting pyrite oxidation under various groundwater conditions.

#### 1.5. Hypothesis

1. It is suspected that the application of organic matter can inhibit the pyrite oxidation process.
2. It is suspected that the treatment by maintaining a 5 cm high puddle of water can inhibit the pyrite oxidation process.
3. It is suspected that the combination of 50 grams of organic matter per kilogram of soil and the treatment of maintaining a 5 cm high ground water puddle is the best treatment in the process of inhibiting pyrite oxidation.

CHAPTER 2  
**LITERATURE REVIEW**

**2.1. Pyrite Oxidation**

Some of the soil that develops in tidal swamp land is soil derived from mineral or organic parent materials which are influenced by tidal and river water. Tides of sea water cause mineral or organic sediments accompanied by reductive components of iron and sulfur to form a layer of pyrite ( $\text{FeS}_2$ ). The process of reducing iron and sulfate oxidation in acid sulfate soils is the main factor that can determine the pH value of the soil. The pH values for acid sulfate soils ranged from <3.5 to pH 4.0. Level high acidity and increasing concentrations of Fe and  $\text{SO}_4^{2-}$  on the ground indicates that pyrite oxidation has occurred (Annisa and Nursyamsi, 2016; Nursyamsi *et al.*, 2014; Lee *et al.*, 2011).

Oxidation of the pyrite layer occurs due to direct contact between pyrite and oxygen that occurs due to the decrease in the groundwater level (MAT) to below the pyrite layer. This condition will cause a reaction between pyrite compounds with oxygen. In very strong pyrite oxidation conditions caused by the exposure of the pyrite layer to oxygen, it will produce the mineral jarosite. The mineral jarosite in oxidized soil will form like straw yellow rust which is very acidic and can be toxic to plants. Jarosite will be stable in oxidized conditions in an acidic environment pH <3 (Annisa and Hasanudin, 2013).

Pyrite oxidation in acid sulfate soils occurs in several stages involving chemical and biological processes. At first dissolved oxygen will react slowly with pyrite to produce iron (II) and sulfate (Masulili, 2015; and Verronet *et al.*, 2019):



After that, the oxidation of sulfur by oxygen proceeds very slowly, but can be catalyzed by autotrophic bacteria at a near neutral pH:



If the pH of the oxidation system is below 4, then Fe<sup>3+</sup> will dissolve in sufficient quantities to cause rapid oxidation of pyrite:



The reaction of iron (III) with sulfur is also very fast and the overall oxidation of pyrite by iron (III) is described as follows:



In very strong oxidation conditions, due to the lifting of marine sediment material to the surface, it will produce jarosite minerals which are seen as straw yellow rusty.

Pyrite oxidation can cause changes in the content of ions in the soil solution and in the adsorption complex (et al., 2011). Pyrite soils that have undergone an oxidation process have a tendency to decrease the pH value of the soil to <3 due to the formation of sulfuric acid. Acidic soil conditions can further increase the solubility of Al, Fe and Mn and decrease soil quality due to the loss of soil bases such as Ca, Mg, K, and Na. Al cations dissolved in the soil can bind P so that it becomes unavailable to plants (Husna, 2014; Das and Das, 2015).

Pyrite oxidation can increase soil acidity which is quite high and can cause the solubility of Al, Fe, and Mn to be very high in the soil solution. High Al, Fe, and Mn solubility can cause nutrient deficiency, if this happens it can disrupt plant metabolic processes and be potentially toxic to plants and water (Harahap, 2014; Chen and Yang, 2019).

## 2.2. Organic ingredients

Organic matter in acid sulfate soils plays a role in maintaining a reducing atmosphere in the soil, a source of energy for sulfate-reducing bacteria, preventing the oxidation of sulfide compounds, and being a buffer from acidity resulting from pyrite oxidation (Subagio, 2019; and Michael, 2010). et al., 2015). According to Yuan et al. (2016), application of organic matter with a low C/N ratio <50 to the soil as much as 30 grams per kilogram of soil can prevent acidification due to oxidation of sulfide materials and can attract cations.

metals such as Al and Fe and liberate a number of nutrients, especially P to be available to plants (Husna, 2014). The addition of organic matter to acid sulfate soils can stimulate an increase in the value of soil acidity or soil pH value (Jayalathet *al.*,2015).

The mechanism of organic matter in inhibiting the occurrence of pyrite oxidation are: 1) Oxygen consumption by bacteria; 2) Binding  $Fe_{3+}$  in the ground; 3) Formation of complexes of pyrite and Fe . compounds<sub>2+</sub> (Sandrawatiet *al.*, 2019; and Ouyanget *al.*, 2014). Oxygen consumption by microbes can inhibit the oxidation process of sulfidic materials due to competition in the use of oxygen by soil microbes to decompose organic matter with the need for oxygen to oxidize pyrite directly (Fahmi and Ratmini, 2017). Bacteriological and organic activities require the availability of oxygen so that it makes these organic processes compete with pyrite for the availability of oxygen in the soil. Bacteriological and organic reactions consume a large amount of oxygen available in groundwater, thus limited oxygen in the soil will significantly slow down the rate and amount of acid produced.

Organic matter that is easily decomposed causes the soil to be more reduced. In this condition the presence of Fe ions<sub>3+</sub> will be reduced to  $Fe_{2+}$  so that it can reduce the rate of pyrite oxidation caused by Fe ions<sub>3+</sub> so that the availability of Fe in the soil is reduced (Luoet *al.*,2016). Organic compounds with non-ionized functional groups such as carbohydrates (polysaccharides) with aldehyde and ketone functional groups can affect the reactions that occur in the soil and can form complex compounds with metal cations such as Fe, so that Fe activity in the soil is reduced. Organic matter added to soil has a number of advantages, including being cheaper and more readily available and can be easily applied or applied in sensitive environments such as in wetlands, where lime application is not recommended (Michaeliet *al.*,2015). The dose of organic matter in this study was 50 grams per kilogram of soil or 130 tons per ha (Yuanet *al.*,2016). The high dose of organic matter is intended to improve soil properties and inhibit the occurrence of pyrite oxidation. On

In general, the need for ameliorant material to improve soil properties is higher than the need for plants.

### 2.3. Water Management in Tidal Swamps

The construction of waterways in tidal areas aims to manage water at the macro and micro levels. The construction of primary, secondary, tertiary, and quarterly waterways is an important matter in water management. The construction and use of these waterways can be adapted to the needs or conditions of the local area in accordance with environmental conditions. Water management at the macro level includes an area that aims to manage the function of irrigation or drainage networks as well as rain storage areas, while water management at the micro level includes water management at the farmer level (Sa'ad, 2012).

Water management in tidal swamps must be carried out more carefully during the dry season, because the availability of water decreases significantly so that it can cause pyrite oxidation and release sulfuric acid (Marsiet *al.*, 2016). The purpose of water management in tidal swamp land is to create conditions so that the groundwater level is always above the pyrite layer so that the pyrite oxidation process can be prevented and does not poison plants, so plants can grow and develop normally.

Pyrite oxidation process will occur if the soil has poor air conditioning or aeration. The groundwater table above the pyrite surface will reduce the diffusion of oxygen into the soil so that the pyrite layer is in a reduced state, this can cause inhibition of the pyrite oxidation process by oxygen (Anwar and Sudadi, 2013). On the other hand, if there is a decrease in the ground water level, it can cause the atmosphere to become oxidative and the availability of oxygen in the soil to increase (et *al.*, 2011). The rate of oxygen diffusion to the soil decreased with increasing inundation height of more than 4 cm. The results of research by Rachmawati and Retnaningrum (2013), stated that at a pool height of 4 cm the number of tillers and plant heights as well as the number of non-symbiotic N-fixing bacteria still increased, but in a puddle of 8 cm it started to decrease or lower.

Controlling groundwater levels in soils with pyrite layers can improve land quality and inhibit pyrite oxidation. According to Soewandita (2018), in his research, he stated that water management by maintaining the groundwater level above the pyrite surface can prevent the occurrence of *overdrainage* and pyrite oxidation. In soils with a pyrite layer at a depth of 100 cm by maintaining the groundwater table more than the pyrite surface can increase oil palm production by 3.8 – 4.5 tons of FFB per ha per year compared to oil palm production on land with a pyrite depth of 50 cm and a groundwater table above 50 cm.

CHAPTER 3  
**RESEARCH IMPLEMENTATION**

**3.1. Place and time**

The soil used in this study was taken from tidal land in Mulyasari Village, Tanjung Lago District, Banyuasin Regency. This research was carried out in the Greenhouse of the Soil Department, Faculty of Agriculture, Sriwijaya University and soil analysis was carried out at the Chemistry, Biology and Soil Fertility Laboratory, Department of Soil, Faculty of Agriculture, Sriwijaya University, Indralaya, from October 2020 to November 2020.

**3.2. Materials and Methods**

The materials used in this study were 1) Distilled water; 2) Compostable ameliorant material; 3) Laboratory Analysis Materials; 4) Pyrite soil samples.

The tools used in the implementation of this research are 1) Laboratory Analysis Tools; 2) belgian drill; 3) Hoe; 4) Duct tape; 5) Meters; 6) Airtight plastic; 7) Plastic jar.

This research was conducted in a greenhouse according to a Completely Randomized Factorial Design (RALF) with two factors, namely the dose of ameliorant and groundwater conditions. The treatments that were tried were:

**1. Dosage of Ameliorant B . Ingredients=**

without ameliorant;

**B<sub>1</sub>**= Ameliorant organic matter in the form of compost is added as much as 50 grams per kilogram of soil or the equivalent of 130 tons per ha.

**2. Groundwater Condition**

**K<sub>1</sub>**= 5 cm above the ground and maintained until the end of the study;

**K<sub>2</sub>** = Initial 5 cm at ground level and allowed to decrease naturally during the study.

Each treatment combination was repeated 3 times, so there were 12 experimental units.



### **3.3. Procedure**

#### **3.3.1. Soil Sampling**

Pyrite soil sampling was carried out on tidal land in Mulyasari Village, Tanjung Lago District, Banyuasin Regency. This pyrite soil layer is characterized by the presence of a gray layer and when 1 ml of 70% hydrogen peroxide is added, it will produce foam. Soil samples were taken at a depth of 70-90 cm. The pyrite layer soil sample was put into an airtight plastic container as much as 3 layers and then tied and glued again using clear duct tape. This is done so that the pyrite soil is not in direct contact with oxygen and prevents pyrite oxidation. Soil samples that have been taken from the field are then stored in a closed room and not exposed to sunlight. Documentation of soil sampling and research process is attached in (Appendix 1).

#### **3.3.2. Initial Soil Sample Analysis and Amelioran Characterization**

Soil samples that have been taken are characterized by soil properties before being treated, including pH H<sub>2</sub>O, Dissolved Fe, Dissolved Sulfate, Soil Texture, Water Content, and Soil Pyrite Content. While the characterization of ameliorant materials includes organic, moisture content, and CEC. Characterization of the initial soil and ameliorant samples was carried out once, namely at the beginning of the study before the soil was treated and before the application of the ameliorant material to the soil.

#### **3.3.3. Preparation of Incubation Media and Application of Ameliorant Materials**

Preparation of incubation media was carried out by preparing plastic jars with a jar height of 17 cm and a diameter of 14 cm and preparing a pyrite layer of 21.12 kilograms of soil that had been taken in Mulyasari Village. Each jar was filled with 1.76 kg of pyrite layer (Appendix 2). The ameliorant material used is in the form of organic material in the form of compost as much as 50 grams per kilogram of soil or 130 tons per ha (Appendix 3) and the water used is ion-free water taken from the Chemistry, Biology and Soil Fertility Laboratory, Soil Department, Faculty of Agriculture.

Sriwijaya University Agriculture. Ion-free water required is as much as 850 ml per jar.

The application of ameliorant material in the form of organic material is carried out by mixing organic matter with pyrite layer soil until homogeneous. The mixing process of organic matter and pyrite soil is done by adding water little by little to facilitate the mixing process. After that, water was added until the puddle height reached 5 cm for the treatment of water conditions. In the process of adding water, wait a few moments until the water seeps into the bottom of the soil, if the puddle height is still less than 5 cm then add more water so that the puddle height reaches 5 cm. For the control treatment, the pyrite soil was directly treated with water conditions without the addition of ameliorant.

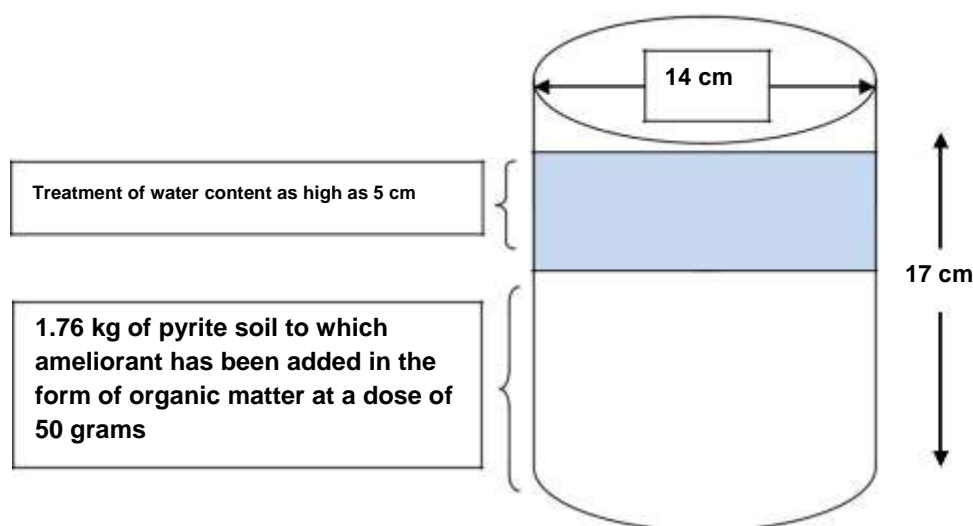


Figure 3.1. Research Devices for Soil Incubation

### 3.3.4. Soil Incubation

Soil incubation was carried out after all experimental units had received the appropriate treatment including controls. All jars that contained soil and had been treated were arranged according to the experimental unit layout plan (Appendix 4). This incubation was carried out for 41 days and was carried out in the Greenhouse of the Department of Soil, Faculty of Agriculture, Sriwijaya University, Indralaya. The observation process was carried out every day during incubation. Observations were made every day on all treatments. In the treatment with standing water conditions maintained

added water every time there is a reduction in the height of the puddle. Meanwhile, in the treatment with standing water conditions, it was allowed to decrease without adding water and the reduction was recorded.

### 3.3.5. Soil Analysis During Research

Soil samples for analysis were taken using a paralon pipe that was placed in the middle of a plastic jar, after that it was put in an airtight plastic bag to prevent pyrite oxidation. Soil samples for analysis of water content, dissolved sulfate and dissolved Fe were taken by composite method. Meanwhile soil samples for pH analysis were taken at each replication. Soil analysis was carried out at the Chemistry, Biology and Soil Fertility Laboratory, Department of Soil, Faculty of Agriculture, Sriwijaya University. Soil analysis was carried out on days 2, 8, 11, 14, 18, 25, 29, 34 and 41. Soil analysis during the study included soil pH analysis, soil dissolved Fe, soil dissolved sulfate, and ground water level.

### 3.4. Observed Variables

The variables observed in this study consisted of:

1. pH H<sub>2</sub>O, Dissolved Fe, Dissolved Sulfate, Soil Texture, Moisture Content, and Soil Pyrite Content were carried out at the beginning of the study before the soil was given treatment.
2. Characteristics of organic matter, including C-organic, moisture content, and CEC, which were carried out once before being applied to the soil.
3. Soil characteristics during the study include, pH H<sub>2</sub>O, Dissolved Fe, Dissolved Sulfate, and soil water content every day 2, 8, 11, 14, 18, 25, 29, 34 and 41.

### 3.5. Data analysis

The data collected by replication were statistically analyzed using ANOVA (*analysis of variance*) and a further test, namely the Honestly Significant Difference (BNJ) test. Data collected without replication was analyzed using ANOVA with quasi-replicate and the relationship between several variables were analyzed using regression and presented in graphical form.

CHAPTER 4  
**RESULTS AND DISCUSSION**

### 4.1. Soil Analysis Before Research

The results of the analysis of several soil chemical properties at the research site are presented in Table 4.1.

**Table 4.1. Soil Characteristics Before Treatment.**

Parameter	Unit	Analysis Results
<b>pH H<sub>2</sub>O</b>		<b>4.92</b>
Water content	%	76.93
<b>Pyrite Level</b>	%	<b>3.6</b>
Dissolved Sulfate	ppm	449.11
Dissolved Fe	ppm	172.50
<b>Soil Texture</b>		<b>Clay</b>
<b>Sand</b>	%	<b>42.40</b>
<b>Dust</b>	%	<b>25,60</b>
<b>clay</b>	%	<b>32</b>

**Source** : Data analysis results in the Laboratory of Chemistry, Biology, and Soil Fertility Department of Soil, Faculty of Agriculture, Sriwijaya University.

The results in Table 4.1 show that the soil sample at the study site belongs to the category of soil with an acid pH of 4.92. The water content in the initial soil sample was high, namely 76.93% this was because the sampling was carried out at a depth of 70-90 cm, where at that depth the soil was in a water-saturated condition.

Pyrite content in the initial soil sample based on the results of the analysis in laboratory is 3.6%. According to Subiksa and Sukristyonubowo (2021), pyrite levels in acid sulfate soils generally range from 1% to 4% and in severe conditions can reach 6% to 7%. Based on this, the pyrite contained in the soil samples before the study was classified as moderate. The results of the texture analysis in the laboratory showed that the soil texture in the initial soil sample was clay. Meanwhile, the values of dissolved Fe and dissolved sulfate in the initial soil samples were 172.50 ppm and 449.11 ppm. Calculation of the results of the initial soil sample analysis is attached in (Appendix 5).

#### 4.2. Characteristics of Organic Ingredients

The organic material used in this research is organic material in the form of compost. The results of the analysis of the characterization of the compost used in this study are presented in Table 4.2.

Table 4.2. Compost Characteristics.

Parameter	Unit	Analysis Results
Water content	%	41.17
C-Organic	%	24.75
Kindergarten	me 100g <sup>-1</sup>	20.08

Source: Data analysis results in the Laboratory of Chemistry, Biology, and Soil Fertility Department of Soil, Faculty of Agriculture, Sriwijaya University.

Based on the results of the analysis that has been carried out the compost used in this study has a C-Organic content of 24.75% with a water content of 41.12%. The results of the analysis of C-organic and the moisture content of the compost used in this study met the quality standard of solid organic fertilizer based on SNI: 19-7030-2004 (Appendix 6). While the value of CEC in compost is low, namely 20.08 me 100g<sup>-1</sup>. Calculation of the results of the characterization of organic matter is attached in (Appendix 7).

#### 4.3. Soil Characteristics During Research

##### 4.3.1. Inundation Conditions and Soil Water Content

The results of the observation of the dynamics of the height of the puddle in the treatment that were allowed to dry during the study (K<sub>2</sub>) is presented in Table 4.3.

Table 4.3. The height of the puddle in the treatment that was allowed to dry for study.

Treatment	The height of the puddle (cm) on the incubation day				
	2	8	11	14	18
B <sub>0</sub>	5	3.5	2.1	1.2	0
B <sub>1</sub>	5	3.3	2.2	1.3	0

Source : Data from observations during incubation in the Soil Department Greenhouse Sriwijaya University Faculty of Agriculture.

The condition of the height of the puddle which can be seen in Table 4.3 shows that during the incubation process from day 2 to day 14 there was a reduction in the height of the puddle. The height of the puddle on day 14 ranged from 1.2 cm to 1.3 cm. On day 18 to day 41 the condition of the inundation height was exhausted or dried up. In Table 4.3, it can be seen that there was no significant difference in the height of the puddle between the treatment without organic matter and the treatment with organic matter. The rate of decrease in the height of the puddle showed a pattern that was not much different between the two treatments. The results of the regression between the incubation time on the treatment without organic matter and with organic matter on the inundation height on day 2 to day 18 are presented in Figure 4.1.

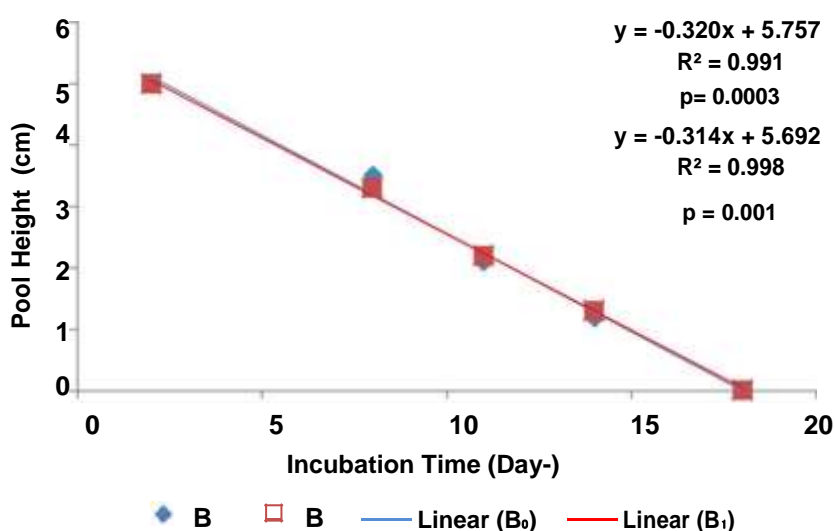


Figure 4.1. Regression graph between incubation time and inundation height in treatment without and with organic ingredients

In Figure 4.1 it can be seen that the incubation time has a linear and significant effect on the decrease in inundation height in the treatment without organic matter and treatment with organic matter with p value = 0.0003. The value of determination indicates that the length of incubation time can affect the decrease in inundation height from day 2 to day 18. Based on the equation in Figure 4.1, there is a decrease in inundation height of 0.320 cm and 0.314 cm per day, respectively for the treatment without and with organic matter. The incubation process is carried out in the Department's Greenhouse

Soil from the Faculty of Agriculture, Sriwijaya University, so that the longer the incubation period, the higher the inundation will decrease. One of the factors that causes the condition of standing water to continuously decrease from day 2 to day 18 is the process of evaporation or evaporation which results in a continuous decrease in inundation height and water content until the end of the study. According to Nafilaet *al.* (2018), the temperature inside the greenhouse building is relatively higher than the temperature outside the building. This is due to the high intensity of heat originating from solar radiation captured by the roof of the building and most of it will be trapped inside the building. The difference in temperature inside and outside the building on average is 5°C in the morning, 3°C during the day, and 1°C at night. Furthermore, the water content data is presented in Table 4.4.

**Table 4.4. The water content data in the treatment that was allowed to dry for study.**

Treatment	Moisture content (%) on incubation day				
	18	25	29	34	41
<b>B<sub>0</sub></b>	112.55	65.04	50.68	13.8	9.09
<b>B<sub>1</sub></b>	101.92	69.47	38.25	16.32	8.75

Source: Data analysis results in the Laboratory of Chemistry, Biology, and Soil Fertility Department of Soil, Faculty of Agriculture, Sriwijaya University.

The data presented in Table 4.4 are water content data with treatments that were allowed to dry on day 18 to day 41. This was because in the treatment conditions, the water that was allowed to dry during the study on incubation days 2 to day 14 was still in good condition. saturated or inundated, then the water content is calculated from day 18 to day 41 where on that day the inundation height is at a height of 0 cm or has dried up. The water content data showed that on day 41 the water content in each treatment was 9.09% and 8.75%. Calculation of the results of the analysis of water content is attached in (Appendix 8). The results of the regression between the incubation time on the treatment without organic matter and with organic matter on the water content on day 18 to day 41 are presented in Figure 4.2.

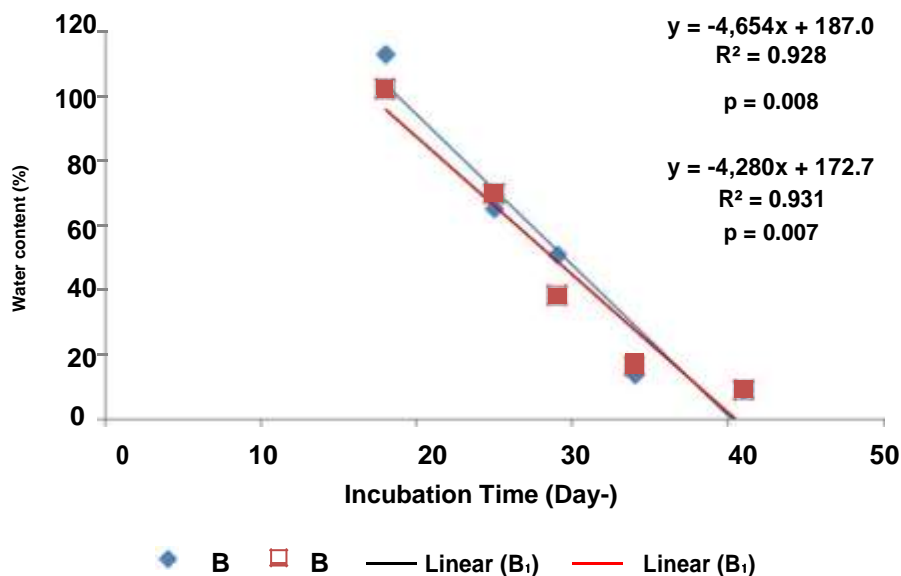


Figure 4.2. Regression graph between incubation time and moisture content in the treatment without and with organic ingredients

In Figure 4.2 it can be seen that the incubation time for the treatment without organic matter and with organic matter had a linear and significant effect on the decrease in water content from day 18 to day 41. Based on the equation in Figure 4.2, the rate of decrease in water content was 4.654% and 4.280. % per day, each for treatment without organic matter and with organic matter. The value of determination indicates that the incubation time can affect the decrease in soil water content. The length of the incubation process resulted in continuous water loss and caused the water content to decrease until the end of the study.

#### 4.3.2. Soil pH Value

Based on the results of the analysis carried out on all soil samples that have been treated in the form of organic matter and water conditions, the results of the average soil pH value between treatments are presented in Figure 4.3.



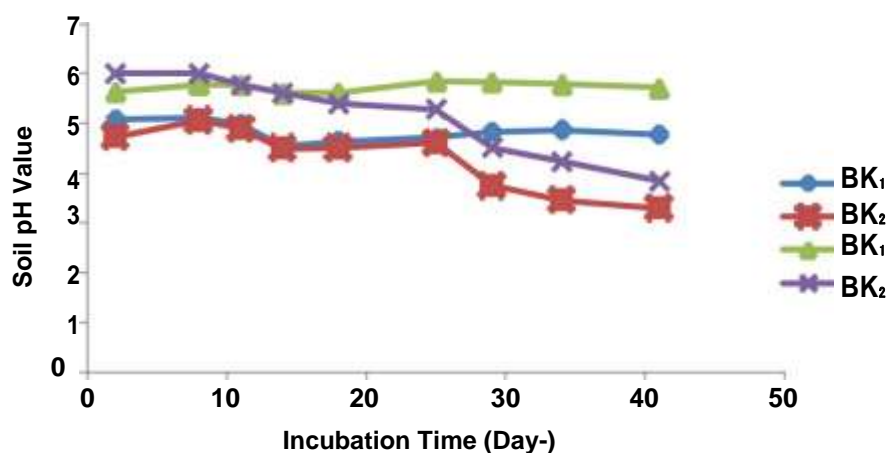


Figure 4.3. Graph of fluctuations in soil pH value during incubation

The graph in Figure 4.3 shows that the 9 observations made during the incubation time can be seen that there is a fluctuation in the pH value of the soil in all treatments. Treatment with organic matter and water conditions maintained during the study (B<sub>1</sub>K<sub>1</sub>), showing the highest pH value, namely 5.71 at the end of the study. Whereas in the treatment without ameliorant and the condition of the water content that was left during the study (B<sub>0</sub>K<sub>2</sub>), is the treatment with the lowest soil pH value of 3.3. The results of ANOVA (Appendix 9) on day 41 showed that the treatment of organic matter and water conditions during the study had a significant effect on changes in soil pH values. Further test results are presented in Table 4.5.

Table 4.5. Effect of Organic Matter and Groundwater Conditions on pH Value Soil At Last Observation.

Water Condition (K)	Soil pH Value		Average
	Organic Ingredients (B)		
	B <sub>0</sub>	B <sub>1</sub>	
K <sub>1</sub>	4.7 <sub>c</sub>	5.7 <sub>d</sub>	5.2 <sub>b</sub>
K <sub>2</sub>	3.3 <sub>a</sub>	3.8 <sub>ab</sub>	3.5 <sub>a</sub>
Average	4 <sub>a</sub>	4.7 <sub>b</sub>	
BNJ <sub>Interaction (5%)</sub> = 0.5		BNJ K 5% = 0.4	BNJ B 5% = 0.4

Description: Numbers followed by different letters in rows and columns

the same one showed a significant difference based on the BNJ test at 5% level.

The results of the honest difference test (BNJ) showed that the treatment of the ameliorant material was maintained in a standing water condition (B<sub>1</sub>K<sub>1</sub>) is a combination

the treatment with the best soil pH value and significantly higher than the soil pH in the other treatments. According to Fahmi and Ratmini (2017), the application of organic matter to acid sulfate soils can maintain a reducing atmosphere, increase oxygen consumption in the soil by microbes which results in competition for oxygen use by microbes, and binds  $Fe^{3+}$  in the soil so that the pyrite oxidation process caused by oxygen and  $Fe^{3+}$  ions which can affect soil pH can be suppressed. Treatment of water conditions maintained until the end of the study ( $K_1$ ) also affects the pH value of the soil, this is because the oxygen content in the flooded soil will decrease and create a reduction atmosphere so that oxygen cannot be in direct contact with the pyrite layer. In the reduction conditions due to flooding, a  $Fe^{3+}$  reduction process will occur to  $Fe^{2+}$ . Therefore, the oxidation of pyrite by oxygen and  $Fe^{3+}$  ions which affects soil pH can be suppressed by giving ameliorant in the form of organic matter by maintaining the condition of the groundwater table above the pyrite layer (Anwar and Sudadi, 2013).

The pH value of the treatment without ameliorant and the condition of the water allowed to decrease naturally until the end of the study ( $B_0K_2$ ) is the lowest with an average pH of 3.3. Based on this, it can be seen that in treatment  $B_0K_2$  has undergone a pyrite oxidation process both by oxygen and by  $Fe^{3+}$  ions which causes a decrease in the pH value of the soil. In observing the condition of the water content, it can be seen that in the treatment  $B_0K_2$  is a treatment with the condition of standing water has dried up and the soil water content at the end of the study was 9%.

The decrease in water content causes cracks on the soil surface which can cause the oxygen supply to the soil to increase, resulting in direct contact between oxygen and the pyrite layer and can reduce the pH value of the soil to become very acidic, this is in line with Yuliana's (2012) statement, the occurrence of oxidation Pyrite will produce sulfate compounds and cause the soil reaction to become very acidic. In addition, the pH value of the soil in acidic sulfate soils is one indicator of the occurrence of pyrite oxidation which causes a decrease in soil pH to become very acidic, namely

below 4 (Gazali and Fathurrahman, 2019). The relationship between water content and pH value in the treatment without and with organic matter in the condition of the water being allowed to dry is shown in Figure 4.4 and Figure 4.5.

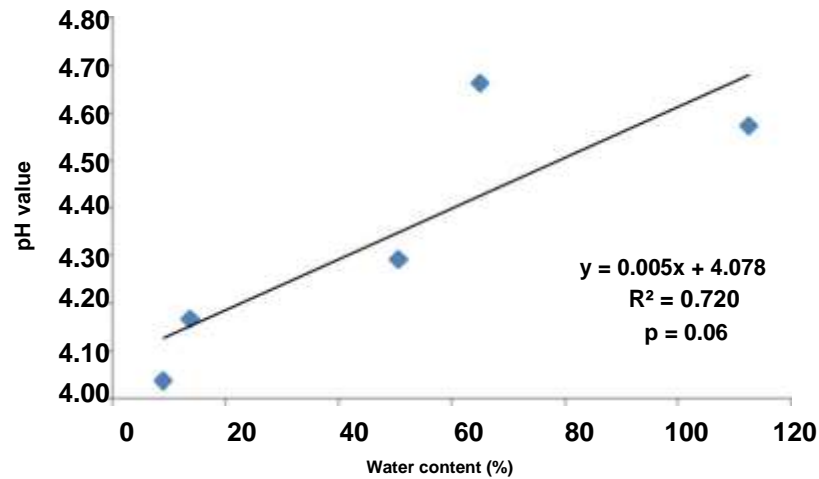


Figure 4.4. Regression graph between soil content and pH in the treatment without ingredients organic and water conditions allowed to dry

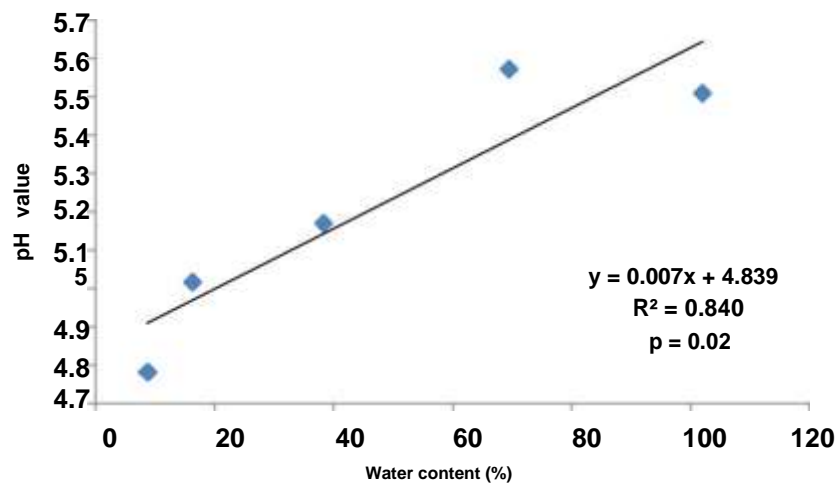


Figure 4.5. Regression graph between water content and soil pH on treatment with organic matter and water conditions allowed to dry

In Figure 4.4 it can be seen that there is a linear relationship between water content and soil pH in the treatment without organic matter with the water being allowed to dry, showing insignificant results with p value = 0.06. While the linear relationship between water content and soil pH in the treatment with

organic matter (Figure 4.5) showed significant results with  $p$  value = 0.02. Based on the regression equation, the rate of decrease in soil pH was 0.005 units for every 1% decrease in water content in the treatment without organic matter and 0.007 units for every 1% decrease in water content in the treatment with organic matter. The relationship between inundation height and soil pH in the treatment without and with organic matter under conditions of water allowed to dry is presented in Figure 4.6 and Figure 4.7.

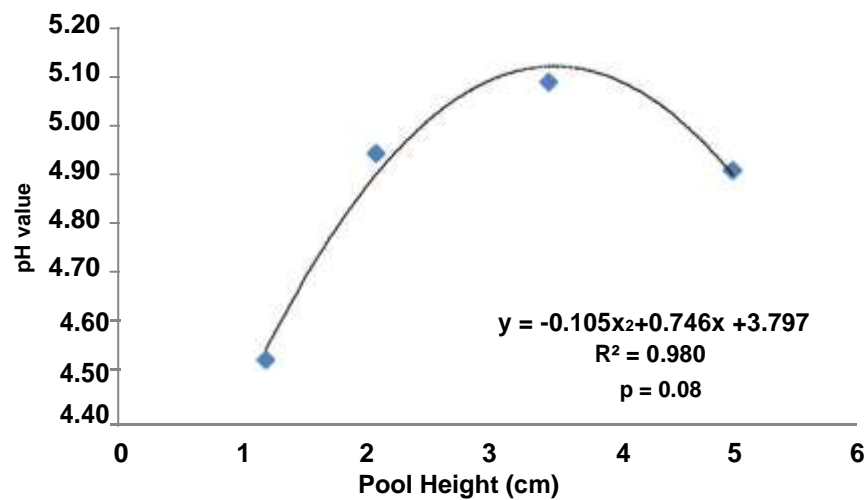


Figure 4.6. Polynomial graph between inundation height and soil pH in treatment without organic matter and water conditions allowed to dry

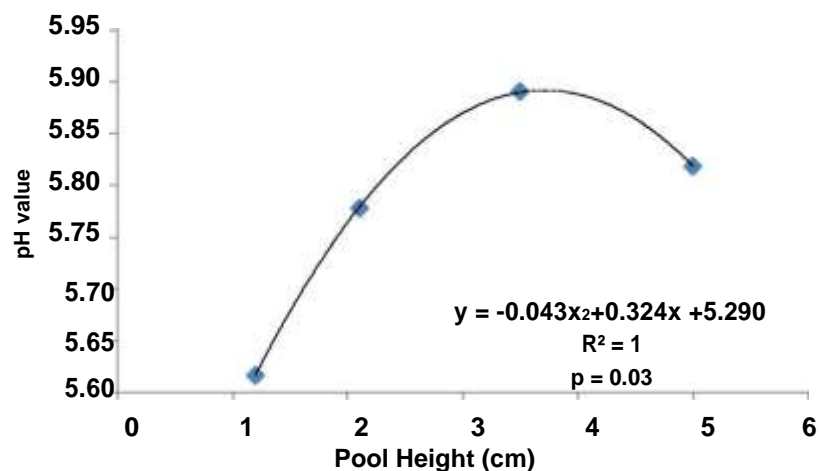


Figure 4.7. Polynomial graph between inundation height and soil pH in treatment with organic matter and water conditions allowed to dry

The results of the regression analysis between inundation height and soil pH in the treatment with water left to dry showed an insignificant quadratic relationship with  $p = 0.08$  and significant  $p = 0.03$  for the treatment without organic matter (Figure 4.6.) and with organic matter (Figure 4.7). Based on the obtained quadratic equation, there was a rate of change in the soil pH value of  $-0.21x + 0.746$  and  $-0.086x + 0.324$  for every 1 cm decrease in puddle height, in the treatment without and with organic matter, respectively. In Figures 4.6 and 4.7, it can be seen that at 3 cm inundation the pH value of the soil reaches its maximum point, which is more than 5.5. This is caused by flooding and the addition of organic matter which creates a reduction atmosphere. After that there was a decrease in the pH value of the soil along with a decrease in the height of the puddle. Based on the results of Cyio's research (2016), it is stated that the pH value of the soil will increase if the inundation height increases.

#### 4.3.3. Soil Dissolved Sulfate and Dissolved Fe

##### 4.3.3.1. Soil Dissolved Sulfate

Based on the results of the analysis carried out on all soil samples in the treatment without and with organic matter and the condition of the water being maintained or allowed to dry, the results of the dissolved sulfate values of the soil during the study are presented in Figure 4.8.

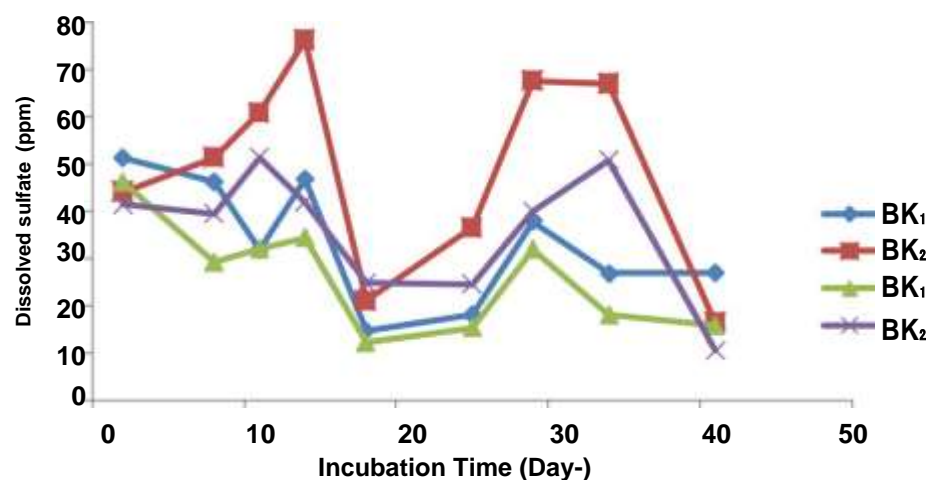


Figure 4.8. Graph of fluctuations in the solubility of sulfate in the soil during the study

Based on the graph in Figure 4.8 the treatment with water conditions maintained during the study had lower soil dissolved sulfate values compared to the two treatments with water conditions allowed to decrease naturally during the study. The results of ANOVA showed that the treatment of organic matter and water conditions did not significantly affect the solubility of sulfate in the soil during the incubation period (Appendix 10). Furthermore, fluctuations in the solubility of sulfate in the soil with treatment without organic matter or with organic matter during the study are presented in Figure 4.9.

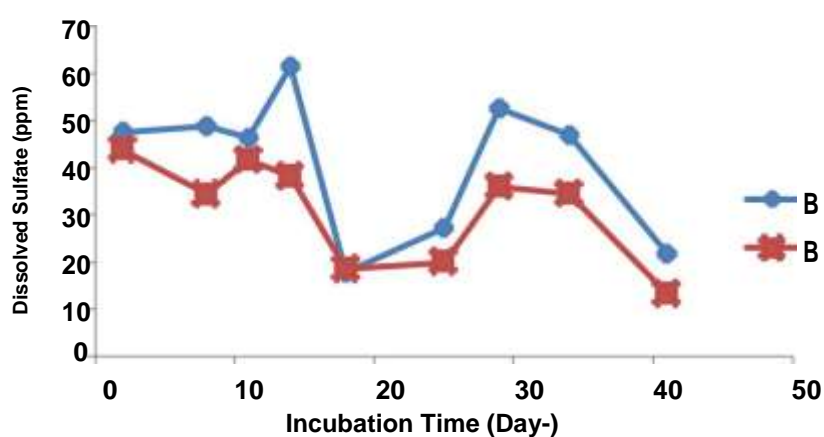


Figure 4.9. Graph of fluctuations in the solubility of sulfate in the soil in the treatment without ingredients organic and with organic ingredients

In Figure 4.9 it can be seen that the solubility of sulfate in the treatment with organic matter (B<sub>1</sub>) was lower than the treatment without organic matter (B<sub>0</sub>). In addition to the inundation process, the addition of organic material in the form of compost can also reduce the solubility of sulfate in the soil. This is in line with Juhrian's statement *et al.*(2020); Subiksa and Sukristyonubowo (2021), organic matter can increase the number of sulfate-reducing bacteria in the soil and can create a reducing atmosphere in the soil. In a reduction atmosphere, it can increase the growth of aerobic sulfate-reducing microbes and utilize the energy derived from the sulfate reduction process as an electron acceptor to produce H sulfide.  $S^{2-}$  very quickly. This is in line with the statement of Ramadan *et al.*(2018), in his research stated that sulfate-reducing bacteria utilize H<sub>2</sub> donors and C derived from organic materials. Fluctuations in sulfate solubility on treatment with different water conditions

maintained ( $K_1$ ) as well as in water conditions that were allowed to dry during the study ( $K_2$ ) is presented in Figure 4.10.

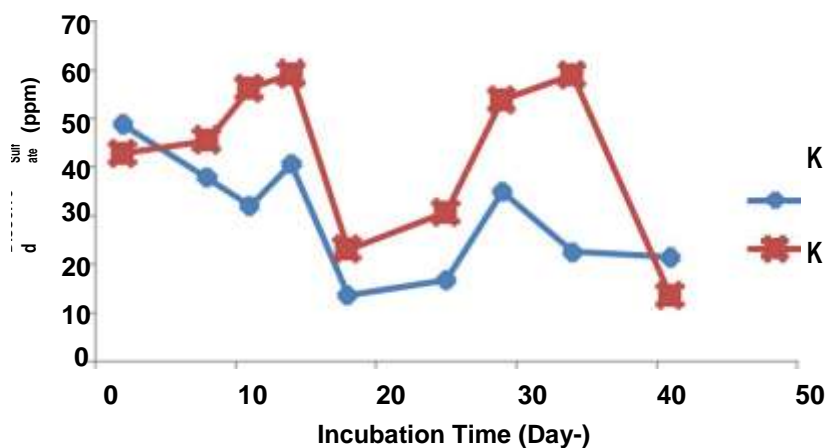


Figure 4.10. Graph of fluctuations in the solubility of sulfate in the soil under treatment of water conditions maintained ( $K_1$ ) and left to dry ( $K_2$ )

Based on Figure 4.10 it can be seen that the pattern of the rate of fluctuation of the sulfate solubility in the soil in the  $K_1$  and  $K_2$  have the same pattern. In the  $K_1$  treatment lower sulfate solubility and stable compared to the  $K_2$  treatment. This is due to the sulfate reduction process which causes the formation of  $H_2S$  so that the sulfate level decreases (Yuliana, 2012). The high solubility of sulfate in the soil in the  $K_2$  after the 18th day due to a decrease in the height of the puddle and water content. The decrease in water content until the 18th day until the end of the study caused the Sulfide contained in the soil to react with oxygen to form  $H_2SO_4$  (Juhriana *et al.*, 2020). This process can increase the value of dissolved sulfate in the soil. According to McCauley (2017), besides being caused by direct contact with oxygen, sulfate oxidation can occur due to the presence of sulfate-oxidizing microbes to produce sulfate ( $SO_4^{2-}$ ) and  $H^+$ , this can cause a decrease in the pH value of the soil. It can be seen in Table 4.5 the pH value of the  $K_2$  treatment soil is the lowest with an average pH value of <4. This shows that there has been a process of oxidation of sulfide materials by oxygen and by microbes.

At the end of the study, it can be seen that the K . treatment<sub>2</sub> experienced a drastic decrease in the value of dissolved sulfate, even the value of dissolved sulfate K . treatment<sub>2</sub> at the end of the study was lower than the K . treatment<sub>1</sub>. According to Yuliana (2012), the longer the drying process, the lower the sulfate content due to the high mobility and lability of the sulfate anion. The position of unstable soil sulphate values in the soil causes the distribution of sulphate in acid sulphate soils to be erratic. In some cases it was found that the pH of the acid sulfate soil was low but the dissolved sulfate level was still low. The regression results between water content and inundation height in the treatment without organic matter and with organic matter in the condition of the water being allowed to dry on the sulfate solubility in the soil on day 18 to day 41 showed insignificant results with a coefficient of determination  $<0.5$  .

#### 4.3.3.2. Soil Dissolved Fe

At the beginning of the study, all the treated soils were in a reductive condition, that is, they were treated with puddles with a height of 5 cm. In reductive or flooded conditions, a Fe . reduction process will occur<sub>3+</sub>to Fe<sub>2+</sub> (Susilawati and Fahmi, 2013). Soil Fe values are presented in Figure 4.11.

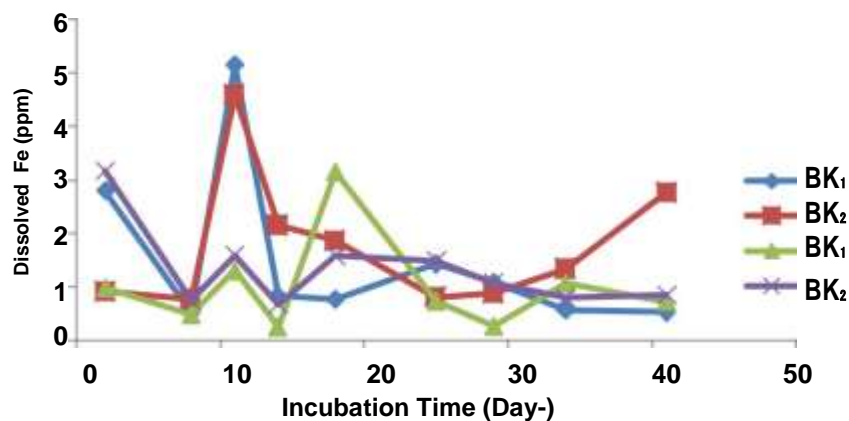


Figure 4.11. Graph of fluctuations in the solubility of Fe in the soil during the study



In Figure 4.11 it can be seen that the treatment with the lowest Fe solubility was in the treatment with organic matter and water conditions were maintained during the study ( $B_1K_1$ ) while the highest Fe solubility was in the treatment without organic matter and water conditions were allowed to dry during the study ( $B_0K_2$ ). The results of ANOVA showed that the treatment of organic matter and water conditions had a significant effect on the solubility of Fe in the soil only on day 8 after incubation (Appendix 11). Furthermore, fluctuations in the solubility of Fe in the treatment without organic matter and with organic matter during the study are presented in Figure 4.12.

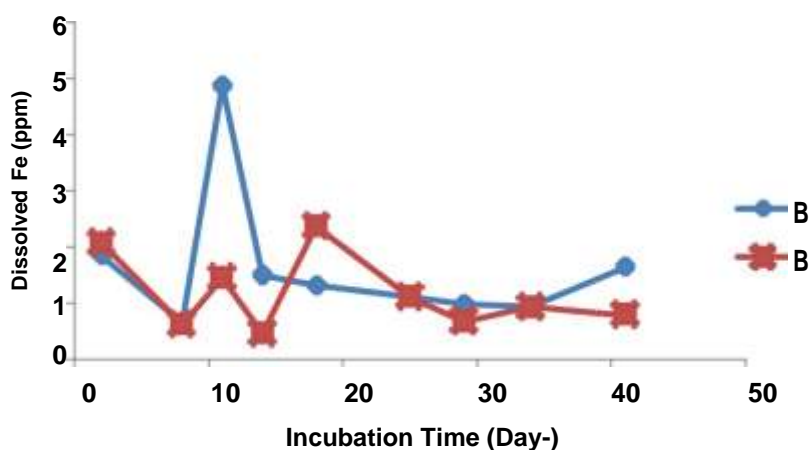


Figure 4.12. Graph of fluctuations in the solubility of Fe in the soil in the treatment without and with organic ingredients

In Figure 4.12 it can be seen that the solubility of Fe in the soil in the treatment without organic matter ( $B_0$ ) was stable from day 14 to day 41, in contrast to the treatment of organic matter ( $B_1$ ) the solubility of Fe in the soil was relatively stable during the study. The rate of fluctuation of Fe solubility in the treatment with organic matter began to stabilize on day 18 to day 41. Application of organic matter could reduce the concentration of Fe in the soil. According to Susilawati and Fahmi (2013), organic materials that have undergone further overhaul and are applied to the soil will produce compounds in the form of humic materials that play a role in reducing Fe concentrations. <sup>2+</sup>, this happens because the chelation process is more dominant than the reduction process by these materials to Fe. In some observations the solubility of Fe

This increase can be caused because compost is an electron donor and as energy for iron-reducing bacteria to reduce ferrous iron to ferrous, causing the concentration of  $Fe^{2+}$  high in the soil (Abduh and Annisa, 2016). Based on this statement, treatment using organic matter can also affect the increase in dissolved Fe concentration in the soil. Besides being caused by the addition of organic matter factors, the solubility of Fe in the soil is also influenced by treatment with maintained inundation conditions ( $K_1$ ) as well as in stagnant water conditions that were allowed to dry during the study ( $K_2$ ). Fluctuations in the solubility of Fe in various water conditions are presented in Figure 4.13.

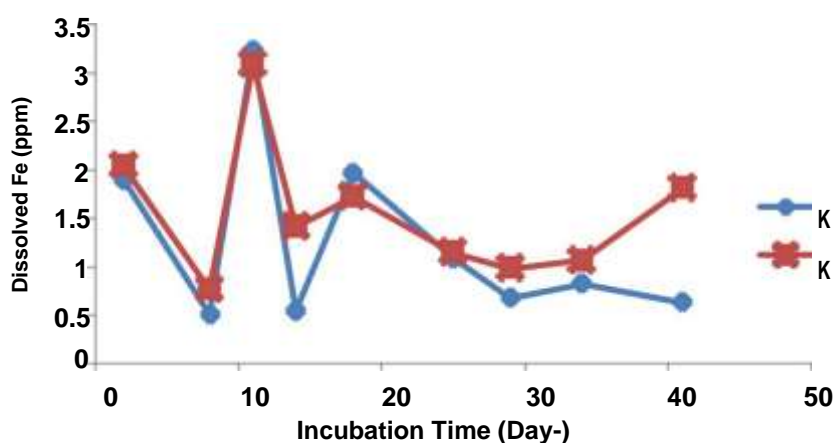


Figure 4.13. Graph of fluctuations in the solubility of Fe in the soil in the treatment of water conditions maintained ( $K_1$ ) and allowed to dry ( $K_2$ )

Based on Figure 4.13 on the treatment that was maintained during the study or was flooded, it can be seen that there was a fluctuation in the solubility of Fe in the soil from day 2 to day 18, after that Fe solubility began to stabilize and decrease until the end of the study. Under flooded conditions,  $Fe^{3+}$  reduction will occur to  $Fe^{2+}$  which causes soil conditions to be very reductive so that the  $Fe^{3+}$  concentration in the soil decreases (Annisa and Subagio, 2016). However, on the 11th day of observation the soil Fe value in the  $K_1$  treatment as well as  $K_2$  is the highest compared to other treatments. This was caused by the inundation, the continuous inundation process after a while resulted in the concentration of Fe in the soil continuously rising to its highest point on day 11, after which it would

There was a process of decreasing Fe concentration even though the soil was still in a flooded condition. The decrease in Fe concentration after reaching the highest point was caused by the reduced availability of Fe<sup>3+</sup>-reduced (Ratmini, 2018; Susilawati and Fahmi, 2013). In contrast to the treatment which was allowed to dry during the study (K<sub>2</sub>) the solubility of Fe in the soil tends to be higher than the previous treatment. On day 18 and day 25, the solubility of Fe in the two treatments was relatively the same, however, on day 29 to day 41, the solubility of Fe in treatment K<sub>2</sub> higher. This is due to the drying process. At the end of the study, it can be seen that the highest soil dissolved Fe value was in the K<sub>2</sub> treatment. The increase in the solubility of Fe in the soil is caused by the occurrence of Fe<sup>2+</sup> oxidation by oxygen to Fe<sup>3+</sup> according to the following reaction:



Fe<sup>3+</sup> value in the soil is influenced by the pH value of the soil, it can be seen in the results of the pH analysis at the end of the study the average value of soil pH with K<sub>2</sub> treatment is <4. This is in line with Suastika's statement *et al.* (2014), Fe<sup>3+</sup> only soluble in soil with a pH below 4. This can also cause the oxidation of pyrite by Fe<sup>3+</sup>. The relationship between the water content of the treatment of organic matter on the solubility of Fe in the soil is presented in Figure 4.14.

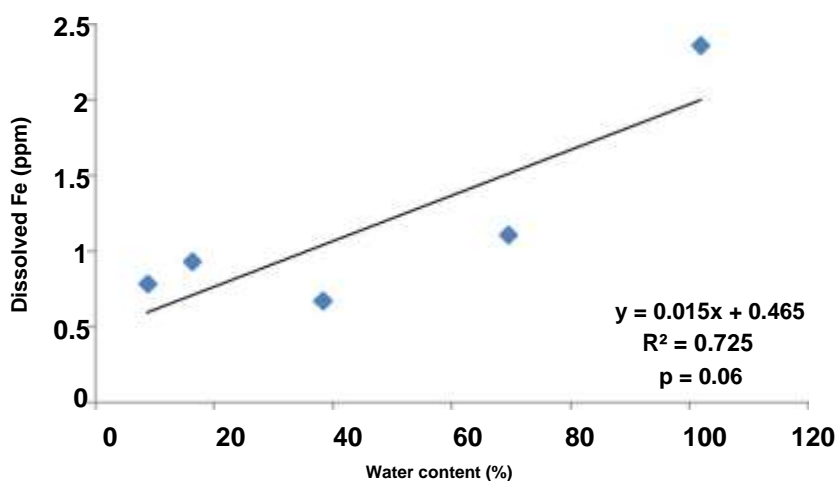


Figure 4.14. Regression graph between water content and soil dissolved Fe in the treatment with organic matter and water conditions allowed to dry

The regression graph in Figure 4.14 shows a non-significant linear relationship between the water content in the treatment with organic matter and the condition of the water allowed to dry during the study on days 18 to 41 on soil Fe solubility with p value = 0.06. Based on the equation  $y = 0.015x + 0.465$ , it can be seen that the rate of decrease in the dissolved Fe value in the soil is 0.015 ppm for every 1% decrease in water content. While the value of determination indicates that the water content in the treatment with organic matter and the condition of the water allowed to dry during the study can affect the soil Fe solubility by 72.5% and 27.5% is influenced by other unknown factors.

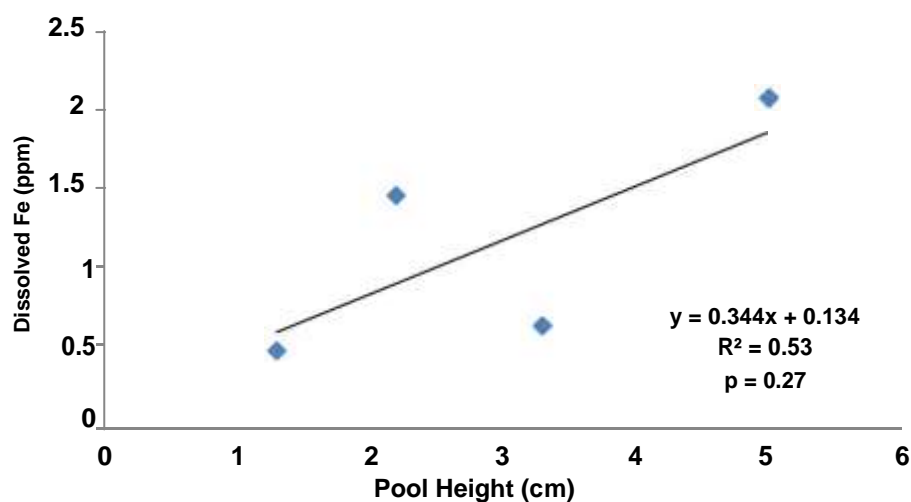


Figure 4.15. Regression graph between inundation height and soil dissolved Fe in treatment with organic matter and water conditions allowed to dry

Based on Figure 4.15, it can be seen that the relationship between the inundation height in the treatment with organic matter and the condition of the water allowed to dry during the study on the solubility of Fe in the soil resulted in an insignificant linear regression with p value = 0.27. The equation  $y = 0.344x + 0.134$  shows a decrease in dissolved Fe by 0.344 ppm for every 1 cm decrease in inundation height. The determination value shows that the inundation height can affect the dissolved Fe value in the soil.

CHAPTER 5  
CONCLUSIONS AND RECOMMENDATIONS

**5.1. Conclusion**

**The conclusions in this study are:**

- 1. Perlakuan dengan bahan organik (B<sub>1</sub>) merupakan perlakuan dengan kadar Fe terlarut dan sulfat terlarut tanah lebih rendah dan pH tanah lebih tinggi dibandingkan dengan perlakuan tanpa bahan organik (B<sub>0</sub>).**
- 2. Perlakuan dengan kondisi air yang dipertahankan (K<sub>1</sub>) merupakan perlakuan dengan kadar Fe terlarut dan sulfat terlarut tanah lebih rendah dan pH tanah lebih tinggi dibandingkan dengan perlakuan kondisi air yang dibiarkan mengering (K<sub>2</sub>).**
- 3. Perlakuan dengan bahan organik dan kondisi air dipertahankan selama penelitian (B<sub>1</sub>K<sub>1</sub>) merupakan perlakuan terbaik dalam mempertahankan pH tanah, Fe terlarut dan Sulfat terlarut serta mencegah terjadinya oksidasi pirit.**

**5.2. Saran**

Adapun saran pada penelitian ini adalah dilakukannya penelitian lanjutan pada berbagai dosis dan/atau jenis bahan organik dalam proses penghambatan oksidasi pirit.

## BIBLIOGRAPHY

- Abduh, AM and Annisa, W., 2016. Interaction of paddy varieties and compost with flux of methane in tidal swampland. *J. Trop Soils*, 21(3), 179-186.
- Annisa, W. and Hasanudin, E., 2013. The role of organic ligands on the formation of iron oxides in acid sulfate soils. *Journal of Land Resources*, 7(1), 37-46.
- Annisa, W. and Nursyamsi, D., 2016. Effect of ameliorants, fertilizers and systems management of acid sulfate soils on rice yields and methane emissions. *Journal of Soil and Climate*, 40(2), 135-145.
- Annisa, W. and Subagio, H., 2016. Analysis of the profile of the effect of organic matter on ferrous iron concentration and absorption in tidal swamp land. *Agricultural Informatics*, 25(2), 241-248.
- Anwar, S. and Sudadi, U., 2013. *Soil Chemistry*. Bogor : Department of Soil Science and Land Resources Bogor Agricultural University.
- National Standardization Agency., 2004. Compost Quality Standards. SNI 19-7030-2004.
- Chen, G. and Yang, H., 2019. Electrochemical study on surface oxidation of natural pyrite in ferric sulfate solution. *int. J. Electrochem. Sci*, 14 (2019), 7047-7061. doi: 10.20964/2019.08.90.
- Cyio, MB, 2016. The effectiveness of organic matter and inundation height on changes in Eh, pH, and status of dissolved Fe, P, Al in ultisol soil. *J. Agroland*, 15(4), 257-263.
- Das, SK and Das, SK, 2015. Acid sulfate soil: management strategy for soil health and productivity. *Popular Kheti*, 3(2), 2-7.
- Fahmi, A. and Ratmini, NPS, 2017. The role of organic matter to improve marginal properties of acid sulfate soil, in: Herlinda., S. *Proceedings of the National Seminar on Suboptimal Land*, Palembang 19-20 October 2017. Palembang: Research Institute for Agriculture and Swamps. 213-223.
- Gazali, A. and Fathurrahman., 2019. *Overview of land aspects in management tidal swamp area in South Kalimantan*. Banjarmasin: Islamic University of Borneo.
- Harahap, SR, 2014. *Adaptation mechanism and suppression of Fe and Al . accumulation to increase rice productivity in tidal land*. Dissertation. Bogor Agricultural Institute.

- Husna, N., 2014. Management of organic matter in acid sulfate soils. *Proceedings National Seminar on Suboptimal Land*, IBA University, September 26-27 2014. Palembang: Agroecotechnology Study Program, Faculty of Agriculture, University of IBA, 821-827.
- Jayalath, N., Fitzpatrick, RW, Mosley, L. and Marschner, P., 2015. Type of organic carbon amendment influences pH changes in acid sulfate soils in flooded and dry conditions. *Journal of Soils and Sediments*, 16(2), 518 – 526.
- Juhrian., Yusran, FH, Wahdah, R. and Priatmadi, BJ, 2020. The effect of Biochar, Lime and Compost on the properties of Acid Sulphate Soil. *Journal of wetlands environmental Management*, 8(2), 157-173.
- Lee, JS, Chon, CM and Kim, JG, 2011. Suppression of pyrite oxidation by formation of iron hydroxide and Fe(III)- silicate complex under highly oxidizing condition. *Korean J. Soil Science. Fert*, 44(2), 297-302.
- Lestari, Y., Ma'as, A., Purwanto, BH and Utami, SNH, 2016. Effect of aeration acid sulfate soil potential to release  $\text{SO}_2$ ,  $\text{Fe}^{2+}$ ,  $\text{H}^+$ , and  $\text{Al}^{3+}$ . *Journal of Soil and Climate*, 40(1), 25-34.
- Luo, Z., Liu, Y., Zhu, R., and Hu, X., 2016. Inhibition of Microbial Pyrite Oxidation by PropS-SH for the Control of Acid Mine Drainage. *int. J. Electrochem. sci.*, 11: 6501 – 6513, doi: 10.20964/2016.08.59.
- Marsi., Susanto, RH and Fitriani, M., 2016. Physical and chemical characteristics of water sources canals in tidal swamp land for aquaculture. *Journal of Fisheries and Marine Affairs*, 21(2), 17-25.
- Masulili, A., 2015. Management of acid sulfate land for development agriculture. *Agrosan Journals*, 12(2), 1-13.
- McCauley, A., Jones, C. and Rutz, KO, 2017. *Soil pH and organic matter*. Montana State University.
- Michael, PS, Fitzpatrick, R. and Reid, R., 2015. The role of organic matter in ameliorating acid sulfate soils with sulfuric horizons. *Geoderma* 11982, 1–8.
- Nafila, A., Prijatna, D., Herwanto, T. and Handarto., 2018. Analysis of the structure and functional greenhouse (case study of experimental gardens and greenhouses, Faculty of Agriculture, Padjadjaran University). *Technotan Journal*, 12(1), 36-49.
- Neira, J., Ortiz, M., Morales, L. and Acevedo, E., 2015. Understanding the factors and processes needed for modeling. *Chilean Journal Of Agricultural Research*, 75 (Suppl. 1), 35-44.

- Nursyamsi, D., Raihan, S., Noor, M., Alwi, M., Maftuah, E., Khairullah, I., Ar-Riza, I., Simatupang, S., Noorginayuwati. and Rina, Y., 2014. *Management of acid sulfate fields for sustainable agriculture*. Jakarta: Agricultural Research and Development Agency.
- Ouyang, Y., Liu, Y., Zhu, R., Ge, F., Xu, T., Luo, Z. and Liang, L., 2014. Pyrite oxidation inhibition by organosilane coatings for acid mine drainage control. *Minerals Engineering*, 72, 57–64.
- Rahmawati, D. and Retnaningrum, E., 2013. Effect of height and duration inundation on the growth of Rice Cultivars Sintanur and population dynamics of non-symbiotic Nitrogen-fixing Rhizobacteria. *Bionatura-Journal of Life and Physical Sciences*, 15(2), 117-125.
- Ramadhan, M., Hanafiah, AS and Guchi, H., 2018. Response of seedling growth Palm oil (*Elaeis guineensis* Jacq.) against the application of Dolomite, fertilizers and sulfate reducing bacteria on acid sulfate soils in greenhouses. *Journal of Agroecotechnology*, 6(3), 432-441.
- Ratmini, NPS, 2018. A study on the province of acid sulfate land in South Sumatra: Case Study of Mulya Sari Village, Tanjung Lago District. *Journal agroecotenia*, 1(1), 52-62.
- Razie, F., 2019. Potential of rice production in acid sulphate soil with depth different pyrite. *Proceedings of the National Wetland Environment Seminar*, Lambung Mangkurat University April 2019. South Kalimantan: Research Institute and Community Service. 92-96.
- Razie, F., Anas, I., Sutandi, A., Sugiyanta. and Gunarto, L., 2013. Efficiency nutrient uptake and yield of rice in SRI cultivation in tidal rice fields using enriched compost. *J. Agron, Indonesia*, 41(2), 89-97.
- Sa'ad, A., 2012. *Changes in land use and regional soil characteristics the tides of Batang Berbak-Pamusir Laut, Jambi*. Bogor: Bogor Agricultural University.
- Sandrawati, A., Suryatmana, P., Putra, IN and Kamaluddin, NN, 2019. Effect of organic matter and sulfate-reducing bacteria on Fe and Mn concentrations in acid mine water remediation. *Soilrens*, 17(1), 38-44.
- Setiawati, E., Prijono, S., Mardiana, D. and Soemarno., 2019. Effect of biochar Durian sawdust on the characteristics of acid sulfate soil in reducing methane gas emissions. *Journal of Soil and Land Resources*, 6(2), 1251-1260.
- Soewandita, H., 2018. A study of peat water management and palm oil productivity on peatlands (Case study: PT Jalin Oil Palm Plantation Peatlands)



- Vaneo in North Kayong Regency, West Kalimantan Province). *Journal of Weather Modification Science & Technology*, 19(1), 41-50.
- Suastika, IW, Hartatik, W. and Subiksa, IGM, 2014. *Characteristics and Acid sulfate land management technology supports eco-friendly agriculture*. Jakarta: Agricultural Research and Development Center.
- Subagio, H., 2019. *Evaluation of the application of rice cultivation identification technology in tidal swamp land*. East Java Agricultural Technology Research Center: Malang.
- Subiksa, IGM and Sukristyonubowo., 2021. *Mitigation of pyrite oxidation impact in tidal swamp management for agriculture*. IOP Conf. Series: Earth and Environmental Science. Bogor: Indonesian Soil Research Institute.
- Susanto, RH, Fitriani, M. and Marsi., 2014. Hydrotophography approach on aquaculture development at the reclaimed tidal lowlands. *Proceeding Seminar of Fisheries and Marine Science*. Pekanbaru 9-10 October 2014.
- Susilawati, A. and Fahmi, A., 2013. The dynamics of iron in acidic sulphate soils planted rice. *Journal of Land Resources*, 7(2), 67-75.
- Sustiyah., Sulistiyanto, Y. and Adji, FF, 2011. Increased knowledge of farmers about the dangers of pyrite ( $\text{FeS}_2$ ) and efforts to overcome it in the tidal agricultural business in the Mentaren area of Central Kalimantan. *AGRIPEAT Journal*, 12(1), 53-60.
- Sutandi, A., Nugroho, B. and Sejati, B., 2011. Relationship of pyrite depth with some soil chemical properties and oil palm production (*Elais guineensis*). *Environmental Soil Journal*, 13(1), 21-24.
- Verron, H., Sterpenich, J., Bonnet, J., Bourdelle, F., Ruck, MR, Lorgeoux, C., Randi, A. and Michau, N., 2019. Experimental study of pyrite oxidation at 100°C : implication for deep geological radwaste repository in claystone. *minerals*, 427 (9), 1-16.
- Yuan, C., Mosley, ML, Fitzpatrick, R. and Marschner, P., 2016. Organic matter addition can prevent acidification during oxidation of sandy hypersulfidic and hyposulfidic material: Effect of application form, rate and C/N ratio. *Geoderma* 276, 26–32.
- Yuliana, DE, 2012. *Test the chemical properties of pyrite soil due to long drying and ground water depth*. Denpasar: Indonesian Hindu University Denpasar.

# **ATTACHMENT**

**Appendix 1. Documentation During Research****Photo 1. Soil Sampling Location****Photo 2. Soil Sampling****Photo 3. Soil Weighing and Ameliorant Mixing Process**



Photo 4. Observation of Puddle Height



Photo 5. Soil Sampling for Laboratory Analysis



Photo 6. Soil Moisture Analysis Process



Photo 7. Observation of Soil pH



Photo 8. Observing the Value of Dissolved Fe, Dissolved Sulfate Using Spectrophotometer



Photo 9. Observation of Soil Texture



Photo 10. Observation of CEC compost



Photo 11. Observation of C-Organic Compost

## Appendix 2. Weight of Soil Used During Research

Soil Moisture Content : 76.93%

$$\begin{aligned}
 \text{Soil weight} &= 1000 \text{ grams} \times \left(1 + \frac{\text{Water content}}{100}\right) \\
 &= 1000 \text{ grams} \times \left(1 + \frac{76.93}{100}\right) \\
 &= 1000 \text{ grams} \times 1.76 \\
 &= 1.76 \text{ kg}
 \end{aligned}$$

## Appendix 3. Calculation of Dose of Organic Matter in Ha.

Known : Organic matter 50g/kg soil (Based on literature)

The soil used is an acid sulfate soil with a soil density of 1.3g/cm<sup>3</sup>

-3

Organic Material Requirement per ha:

- Soil Weight (assuming effective depth 20 cm) W

x H x Bj

$$= 10,000 \text{ m}^2 \times 20 \text{ cm} \times 1.3 \text{ g/cm}^3$$

$$= 10,000 \text{ m}^2 \times 0.2 \text{ m} \times 1.3 \times 10^3 \text{ kg/m}^3$$

$$= 26 \times 10^5 \text{ kg/ha}$$

- Organic Ingredients per ha

$$= \frac{\text{BO}}{\text{Bt.Toples}} \times \frac{\text{BO/ha}}{\text{Bt/ha}}$$

$$= \frac{50 \text{ g}}{1 \text{ kg}} \times \frac{\text{BO/ha}}{26 \times 10^5 \text{ kg/ha}}$$

$$= \frac{0.05 \text{ kg}}{1 \text{ kg}} \times \frac{\text{BO/ha}}{26 \times 10^5 \text{ kg/ha}}$$

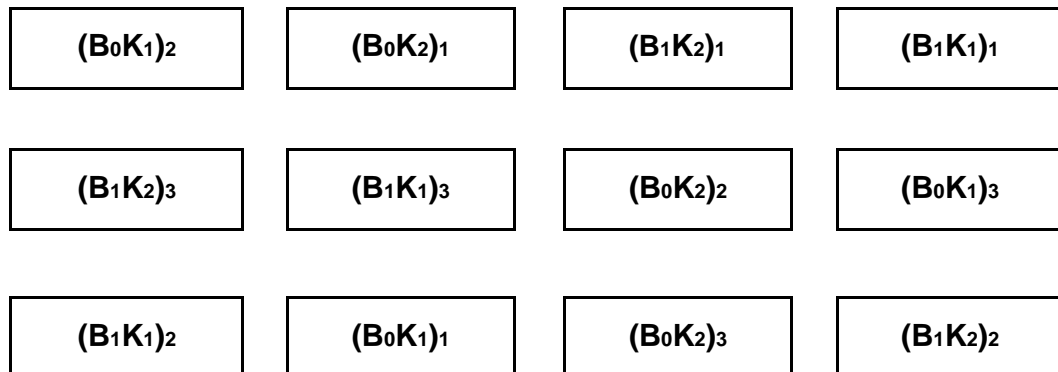
$$\text{BO per ha} = 0.05 \times 26 \times 10^5 \text{ kg/ha}$$

$$= 130,000 \text{ kg/ha}$$

$$= 130 \text{ tons/ha}$$

**Note:** for each jar containing 1 kg of soil, organic matter is needed as much as 50g, while the need per ha is 130 tons of organic matter.

#### Appendix 4. Layout Plan of Experimental Units in the Field



Information :

**B<sub>0</sub>K<sub>1</sub>:** Treatment without ameliorant with standing water condition maintained at 5 cm during the study.

**B<sub>0</sub>K<sub>2</sub>:** Treatment without ameliorant with stagnant water conditions left for study.

**B<sub>1</sub>K<sub>1</sub>:** Treatment with ameliorant with standing water conditions maintained at 5 cm during the study.

**B<sub>1</sub>K<sub>2</sub>:** Treatment with ameliorant with standing water conditions left for study.



## Appendix 5. Initial Soil Sample Characterization Data

## Moisture Content Data Initial Soil Sample

Known: BTB = 19.25 grams

$$\text{BTK} = 10.88 \text{ grams}$$

$$\begin{aligned} \text{Water Content} &= \frac{\text{BTB}-\text{BTK}}{\text{BTK}} \times 100\% \\ &= \frac{19.25-10.88}{10.88} \times 100\% \\ &= 76.93\% \end{aligned}$$

## Data on Pyrite Content of Initial Soil

Samples Known: BTKM = 0.56 gram

$$\text{abs} = 0.343 \text{ ppm}$$

$$\begin{aligned} \text{FeS}_2 &= \frac{50}{\text{BTKM}} \times \frac{10}{1} \times 2,375 \times \text{Abs} \\ &= \frac{50}{0.56} \times 10 \times 2.375 \times 0.343 \\ &= 720.65 \end{aligned}$$

$$\begin{aligned} \text{Pyrite content} &= \frac{\left( \frac{50}{1000} \right) \times (\text{FeS}_2 \times 100)}{1000} \\ &= 3.60\% \end{aligned}$$

## Dissolved Fe Value Data Initial Soil

Sample Known: Abs = 0.2

$$\begin{aligned} \text{Fe} &= \frac{25}{\text{BTKM}} \times \frac{10}{2} \times \text{Abs} \times 3.9 \\ &= \frac{25}{0.56} \times \frac{10}{2} \times 0.2 \times 3.9 \\ &= 172.50 \text{ ppm} \end{aligned}$$

## Dissolved Sulfate Data Initial Soil Sample

Known : Abs = 0.668

$$\text{Sulfate} = \frac{25}{\text{BTKM}} \times \frac{10}{5} \times \text{Abs} \times 7.6$$

$$\frac{25}{10} = 0.56 \times 5 \times 0.668 \times 7.6 = 449.11 \text{ ppm}$$

#### Texture Data of Initial Soil

Sample Known :  $R_1 = 26$

$$R_2 = 10$$

$$\begin{aligned} \% \text{ Sand} &= (w - (R_1 + (T - 20) \times 0.4)) \times 2 \\ &= (50 - (26 + (27 - 20) \times 0.4)) \times 2 \\ &= 42.4\% \end{aligned}$$

$$\begin{aligned} \% \text{ Clay} &= (R_2 + ((T - 20) \times 0.4)) \times 2 \\ &= (10 + ((27 - 20) \times 0.4)) \times 2 = \\ &25.6\% \end{aligned}$$

$$\begin{aligned} \% \text{ Dust} &= 100\% - (\% \text{ Sand} + \% \text{ Clay}) \\ &= 100\% - (42.4\% + 25.6\%) = \\ &32\% \end{aligned}$$

Initial Soil Sample Texture = Clay

**Appendix 6. Table of Compost Quality Standards (SNI: 19-7030-2004)**

Parameter	Unit	Compost Quality Standard	
		Min	Max
C-Organic	%	9.80	32
Water content	%	-	50

**Source : SNI 19-7030-2004**

## Appendix 7. Characterization of Organic Matter Data

## Compost Moisture Content

$$\text{BTB} = 5.04$$

$$\text{BTK} = 3.55$$

$$\begin{aligned} \text{Water Content} &= \frac{\text{BTB}-\text{BTK}}{\text{BTK}} \times 100\% \\ &= \frac{5.04-3.57}{3.57} \times 100\% \\ &= 41.17\% \end{aligned}$$

## Composting C-organic Data

$$\text{It is known that } T = \quad W = 0.1 \text{ gram}$$

$$10.6 \text{ B} = 6.91 \text{ N} = 1$$

$$\begin{aligned} \% \text{ C-Organic} &= (t - b) \times N \times \frac{36}{12000} \times \frac{100}{77} \times \frac{100}{W} \\ &= (10.6 - 6.91) \times 1 \times 0.003 \times 1.298 \times \frac{100}{0.1} \\ &= (10.6 - 6.91) \times 1 \times 0.003 \times 1.298 \times 1000 = \\ &= 14.4\% \end{aligned}$$

$$\begin{aligned} \% \text{ BO} &= 14.36 \times 1.724 \\ &= 24.75\% \end{aligned}$$

## Compost CEC Data

$$P = 8$$

$$\begin{aligned} \text{KTK} &= \frac{20}{1} \times \frac{25}{1} \times \frac{100}{1000} \times 0.05 \times P \\ &= \frac{20}{1} \times \frac{25}{1} \times \frac{100}{1000} \times 0.05 \times 8 \\ &= 20.08 \text{ me/100g} \end{aligned}$$

## Appendix 8. Moisture Content

Treatment	K . Treatment Moisture Content <sub>2</sub> (%) On Incubation Day To-				
	18	25	29	34	41
B <sub>0</sub> K <sub>2</sub>	112.55	65.04	50.68	13.80	9.09
B <sub>1</sub> K <sub>2</sub>	101.92	69.47	38.25	16.32	8.75

**Source** : Data analysis results in the Laboratory of Chemistry, Biology, and Soil Fertility Department of Soil, Faculty of Agriculture, Sriwijaya University.

Calculation of Water Content Treatment B<sub>0</sub>K<sub>2</sub> On Day 41: It

is known: BTB = 5.28 grams

BTK = 4.84 grams

$$\begin{aligned}
 \text{Moisture Content (\%)} &= \frac{\text{BTB} - \text{BTK}}{\text{BTK}} \times 100\% \\
 &= \frac{5.28 - 4.84}{4.84} \times 100\% \\
 &= 9.09\%
 \end{aligned}$$

## Appendix 9. Soil pH Data

### Final Analysis Result Data

Water Condition (K)	Soil pH Value		Average
	Organic Ingredients (B)		
	B <sub>0</sub>	B <sub>1</sub>	
K <sub>1</sub>	4.7	5.7	5.2
K <sub>2</sub>	3.3	3.8	3.5
Average	4	4.7	

**Source** : Data analysis results in the Laboratory of Chemistry, Biology, and Soil Fertility, Department of Soil, Faculty of Agriculture, Sriwijaya University.

### F Test Analysis Results

Sk	Db	Jk	kt	F count	F Table	
					F 5%	F 1%
Treatment	3	10,16	3.38	37.46**	4.07	7.59
B	1	1.66	1.66	18,40**	5.32	11.26
K	1	8.38	8.38	92.68**	5.32	11.26
BK	1	0.11	0.11	1.30 <sub>mr</sub>	5.32	11.26
Error	8	0.72	0.09			
Total	11	10.89				

Information :<sub>mr</sub> = Influence is not real

\* \* = Very real effect

$$KK = \frac{\overline{KT \text{ error}}}{\overline{KT}} \times 100\%$$

$$= \frac{0.09}{17.6} \times 100\%$$

$$= 1.7\%$$

## Appendix 10. Soil Dissolved Sulfate Data

### Analysis of dissolved sulfate using ANOVA.

Summary	Count	Sum	Average	Variance
K <sub>1</sub>	2	42,87211	21,43606	61,38654
K <sub>2</sub>	2	26,91241	13,45621	17,51913
B <sub>0</sub>	2	43,39207	21,69604	55,76044
B <sub>1</sub>	2	26,39246	13,19623	14,57652

**Source** : Data analysis results in the Laboratory of Chemistry, Biology, and Soil Fertility, Department of Soil, Faculty of Agriculture, Sriwijaya University.

### Anova Sulfate

Source of Variation	SS	df	MS	F	P-value	F crit
Water Condition	63.67801	1	63.67801	9.562771	0.199111 <sub>mr</sub>	161.4476
Organic Ingredients	72.24672	1	72.24672	10.84957	0.187644 <sub>mr</sub>	161.4476
Error	6,65895	1	6,65895			
<b>Total</b>	<b>142.5837</b>	<b>3</b>				

Information :<sub>mr</sub> = Influence is not real

### Appendix 11. Soil Dissolved Fe Data

#### Dissolved Fe analysis using ANOVA on day 8.

Summary	Count	Sum	Average	Variance
K <sub>1</sub>	2	1.013181	0.506591	0.000529
K <sub>2</sub>	2	1.520035	0.760017	0.000451
B <sub>0</sub>	2	1.297891	0.648945	0.031798
B <sub>1</sub>	2	1.235325	0.617663	0.032428

**Source** : Data analysis results in the Laboratory of Chemistry, Biology, and Soil Fertility, Department of Soil, Faculty of Agriculture, Sriwijaya University.

#### Anova Fe

Source of Variation	SS	df	MS	F	P-value	F crit
Water Condition	0.064225	1	0.064225	41560.0188	0.0031**	161.4476
Ingredient Organic	0.000979	1	0.000979	633.2624	0.0253**	161.4476
Error	0.000002	1	0.000002			
<b>Total</b>	<b>0.065205</b>	<b>3</b>				

Description: \*\* = Very real effect