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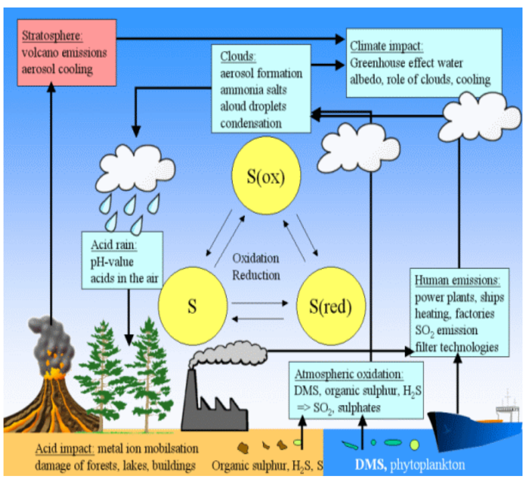
$$FeS_{2(s)} + \tfrac{7}{2} O_{2(g,\ aq)} + H_2O \rightarrow Fe^{2+}_{(aq)} + 2SO_4^{2-}{}_{(aq)} + 2H^{+}_{(aq)}$$

$$Fe^{2+} + \tfrac{1}{4} O_2 + \tfrac{3}{2} H_2O \rightarrow FeOOH \downarrow + 2H^{+}_{(aq)}$$

$$FeS_{2(s)} + \tfrac{7}{2} O_{2(g,\ aq)} + H_2O \rightarrow Fe^{2+}_{(aq)} + 2SO_4^{2-}{}_{(aq)} + 2H^{+}_{(aq)}$$



Water Management of Acid Sulphate Soils in Lowland Areas.

Case Study in Patra Tani, Muara Enim

Resza Dwi Artha

MSc Thesis WSE-HE-LWD-09.09

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Water Management of Acid Sulphate Soils in Lowland Areas. Case Study in Patra Tani, Muara Enim

Master of Science Thesis
by
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Summary

Lowlands are special areas on which water covers the soil or where water is visible either at or near the surface of that soil. Indonesia has about 33.4 million ha lowland, 60% of it is tidal lowland (20 million ha) and the rest is non tidal lowland (13.4 million ha). At several places, lowland soils contain pyrite FeS_2 and other reduced compounds of iron and sulphur. These soils are called potential acid sulphate soils. There are 12.6 million ha of (potential) acid sulphate soils which are distributed all over the world. Indonesia has 2.0 million ha mainly located in the tidal lowlands of South Sumatra, Kalimantan and Papua.

When pyrite is exposed to the air, it can be oxidized. When the oxidation product reacts with water, it will form acid sulphate which causes acid soils. The low pH in soils can constrain plant growth. Therefore, it is important to leach the acidity out of these soils.

This study is dealing with water management for acid sulphate soils in lowland areas mainly focusing on the pyrite development and the leaching process. This research was carried out in Patra Tani, Muara Enim, South Sumatra, Indonesia. It tries to address the following issues: describing the process of acidity development, analyzing and evaluating the factors contributing to the leaching process, simulating proper water management strategies on de-acidification, recommending possible conditions which can make the leaching process a success and create a proper soil condition for the crops.

Leaching is one of the effective and practical ways to remove the acid from the soil, and water is used as a vehicle. More water is applied to the field than is required for crop growth. The water could come from the rainfall or irrigation. This additional water infiltrates into the soil and percolates through the root zone. During percolation, the water takes up part of the acidity from the soil and removes it through the drains. Leaching is influenced by the distance between the drains and the drainage base, soil conditions, intensity and period of rainfall. To optimize this process, it is needed to know how proper leaching can be applied in order to avoid acid in the root zone.

Each type of land use needs a different kind of water management and requires different interventions. Lowland rice calls for inundated fields with possibility for leaching, while dry food crops need stable groundwater tables at depth well below the surface. The focus of water management must be on groundwater control and on preventing stagnant water conditions. In tidal lowlands, there are two basic options for leaching and flushing of the root zone and improving adverse soil-water conditions. The two options involve the drainage option for dry food crops and tree crops and water supply option for wetlands rice.

Water management in tidal lowlands, which becomes possible after water control structures have been installed, aims first of all at realizing optimal agricultural yields. For that purpose, the hydraulic infrastructure of canals and water control structures plays a crucial role, not only for drainage and navigation and locally for irrigation, but also to stimulate crop ripening processes and, where applicable, leaching of acid and toxic elements from the soils. Among others, this implies that stagnant water has to be

avoided. In general, water management takes place at two levels: on-farm water management and main system water management.

Data collection in this study consisted of two main types, primary data collection and secondary data collection. Primary data included soil properties and characteristics, soil chemistry, water level fluctuation, and groundwater level while the secondary data included time series rainfall data, related climate data, general land and soil characteristics in the surrounding area.

In this study, two mathematical models have been used, SMASS and DUFLOW. SMASS is a one dimensional, numerical model that dynamically simulates the transport of water, oxygen, and solutes, together with chemical processes such as pyrite oxidation, weathering of minerals, and cation exchange reactions in the unsaturated as well as in the saturated zone. In this study, two main strategies have been evaluated, i.e.:

- Minimizing the oxidation of the pyrite by keeping the groundwater table as high as possible;
- Maximixing the pyrite oxidation, followed by leaching and flushing of the acid materials from the system.

In addition to SMASS, the DUFLOW model was used to simulate unsteady-state and transient surface-water systems for checking the flushing capacity of the system.

In SMASS model simulation, two cases were developed.

- In Case 1, where the groundwater table was set at 0.2 m-surface, the pyrite will not oxidize. When there is no pyrite oxidation, the pH will be relatively constant, decrease not more than 0.2 point.

- In case 2, the oxidation of pyrite materials has been maximized by setting the groundwater level at a depth of 1.00 m-surface. For the layer between 0.60 to 0.80 m-surface which has 0.2 kg pyrite per m^3 dry soil, it was oxidized completely after 270 days for the upper part and 636 days for the lower part. While at depth of deeper than 0.80 m-surface, which has 10 kg pyrite per m^3 dry soil, it needs longer time. Even after ten years, there is still pyrite content in this layer.

To study the acidity development of pyrite soils, leaching and flushing capacity, land and water management system, a combination between SMASS and DUFLOW models can be used.

Based on the modelling, analysis and evaluation, it is recommended to have more data on soil (physical and chemical) in order to get a more representative result of the model simulation which can be used to support the development plan of this area.

Keywords: Patra Tani, Muara Enim, acid sulphate soils, pyrite, leaching, flushing, SMASS modelling, DUFLOW modelling, tidal lowlands.