# Transformation of pyrite in acid sulfate soils undergoing oxidation in cocoa plantation

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## Introduction

Acid sulfate soils are naturally occurring soils containing pyrite ($FeS_2$) (Dent, 1986). Pyrite is formed in the soils in the presence of ferric and sulfate ions, organic matter and special microorganism. When the soils are drained for agricultural development, the pyrite is exposed and subsequently oxidized, producing sulfuric acid and often releasing large amounts of toxic metals that are harmful to plants. Some of the pyrite crystals may be contaminated with heavy metals such as As, Ni, Co, Pb, Cd and Zn ( Deer et al., 1966). Dissolution of this contaminated pyrite would pollute the soils and the environment (Shamshuddin et al., 1995). Finding a method that can prevent/delay pyrite oxidation under oxidizing environment is desirable for successful implementation of a development project. Phosphate is known to be able to do so. In Malaysia, the area under acid sulfate soils is about 0.5 million ha. Some of these soils are planted to cocoa, which are therefore subjected to the adverse conditions. This study were aimed at reporting the transformation of pyrite in acid sulfate soils under oxidizing environment and to determine the efficacy of applying natural materials to prevent/delay pyrite oxidation.

## Materials and Methods

Two acid sulfate soils namely the Jawa and Linau series, both classified as Typic Sulfaquepts, were sampled. The samples were subjected to pH, organic carbon and mineralogical analyses. The morphology of the unoxidized pyrite present in the Cg-horizon of both soils was studied by SEM-EDAX. The same Cg-horizon samples were incubated in the laboratory for 12 weeks to study the disintegration of pyrite when it was oxidized. Again SEM-EDAX was used for this purpose. Water-soluble metals were determined using AAS and ICP-AES. To study prevention/delaying pyrite oxidation, about 100 g sample containing pyrite was placed in polythene bags. Four types of materials for treatment plus one control were used in this experiment. The treatments were: 1) phosphate; 2) silicate; 3) lime; 4) peat; and 5) control. Ten ml of deionised water was added to each bag and mixed thoroughly. The experiment was arranged in CRD with 3 replications. Sub-samples were taken after 2, 4, 8 and 12 weeks to study pyrite disintegration by SEM-EDAX.

## Results and Discussion

The fresh pH for the soils of Jawa and Linau series was 6.21 and 3.91, respectively. These values were reduced to 4.94 and 2.31 after the soils were oxidized. The lowering of pH was the result of release of protons following pyrite oxidation. Under this condition, Al and Fe were present in large quantities resulting in crop toxicity, for example cocoa. After 12 weeks of incubation, the drop in soil pH was > 1 unit. During the process of oxidation, the acidity so produced attacked clay minerals, releasing more Al to the soils. About 1 % pyrite was present in both soils. This fresh pyrite was clearly observed under SEM. The Fe to S ratio for this unoxidized pyrite was 2:1 as shown by SEM-EDAX, and there was no indication of the pyrite being contaminated with heavy metals. During oxidation, pyrite morphology disintegrated. At the end of the oxidation a new mineral named jarosite was formed; the morphological feature of this mineral was clearly different from that of pyrite. In this study, it was found that the pyrite was free from Cd and As. Hence, the opening of land covered by acid sulfate soils in Malaysia would not contribute to As and Cd pollution. Phosphate is an essential fertilizer, being applied regularly to ensure crop growth. If its presence can somewhat prevent/delay pyrite oxidation, it adds value to its utilization. In this study, it was seen that pyrite in the presence of phosphate appeared to be similar to its unoxidized structure. The amounts of Fe-jarosite in the phosphate-treated samples were much smaller compared to the control. This shows that phosphate application did contribute to the prevention/delaying of pyrite oxidation. It was possible that the presence of phosphate lead to the formation of insoluble iron phosphate which coated the pyrite crystals, thus prevented oxidation. Further indication of the delay in the oxidation of pyrite in the presence of phosphate was shown by pH which was not lowered.

## Conclusions

This study indicated that pyrite in acid sulfate soils of Malaysia is free of heavy metal contamination and phosphate is able to prevent/delay pyrite oxidation.

## Benefits from the study

Generation of new scientific information and availability of a method for sustainable management of acid sulfate soils.

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## Project Publications in Refereed Journals:

Nil

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*Expertise Development*

| Name of Graduate | Degree Awarded | Field of Expertise | Graduation Year |
|---|---|---|---|
| Muhrizal Sarwani | PhD | Soil mineralogy/chemistry | 2001 |

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