

1. Introduction

- **Indonesian peats** (called as ***gambut***) are categorized as **Histosol(s)**, consisting mostly of accumulated organic matter ($\geq 65\%$) [Andriesse, 1988] that are partially derived from decayed vegetation.
- **Materials of the peat** are deposited in **ACIDIC & ANAEROBIC** conditions.
- **In the natural state**, peat deposits covered by forest vegetation are called as **PEAT SWAMP FORESTS**.
- Therefore, **PEAT DEPOSITS** are naturally composed of :
 - (i) **main components** (trees: trunks, branches, leaf, & root),
 - (ii) components of under ground, such as shrubs, grasses, and ferns,
 - (iii) dead macro & micro organisms.



1.1.

Some inherent properties of the Indonesian peat

- ▶ High porosity and very high water content
- ▶ One of the main peat-properties is irreversible drying: meaning that the peat materials would not be able to reabsorb water.
- ▶ Peats are poor in nutrient content, but rich in wood dominated by high content of lignin.
- ▶ The loss of C from peats that has been emitted to the atmosphere; the current annual average emission was estimated to be 903 Mt CO₂ [BAPPENAS, 2009]

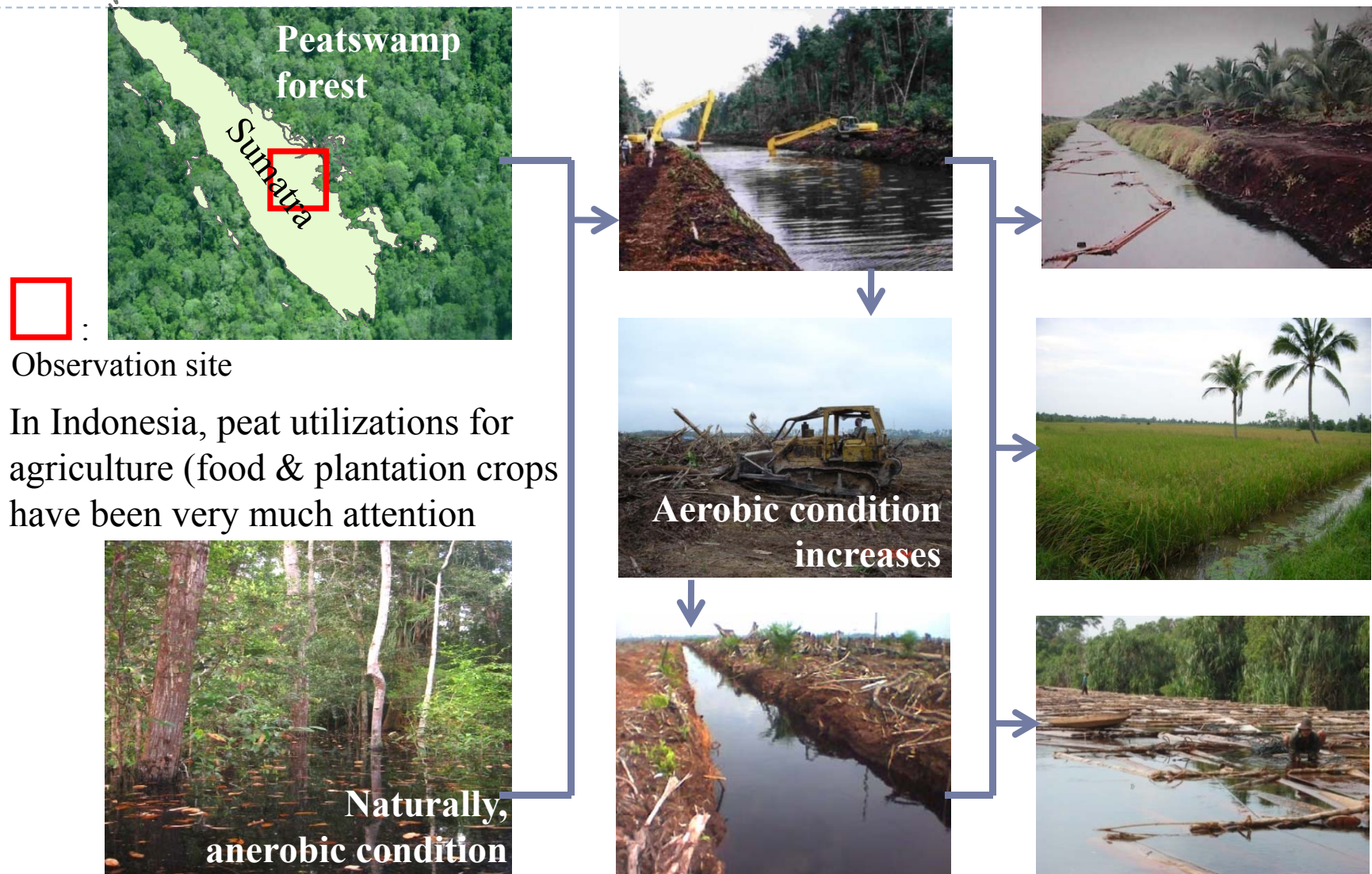
Peat properties	Range
Total porosity (%)	88 – 93
Water content (%)	540 – 835
Irr. drying (minute)*	90 – 135
Tot cont. of nutrient (%)**	
(P ₂ O ₅)	0.05 – 0.24
CaO	0.14 – 2.90
MgO	0.03 – 0.15
K ₂ O	0.02 – 0.12
Lignin (%)	65 - 93

*) Peats were dried at 50 °C;

**) In the peat layer of 0-40 cm

1.2.

Peat utilization for other uses in Indonesia



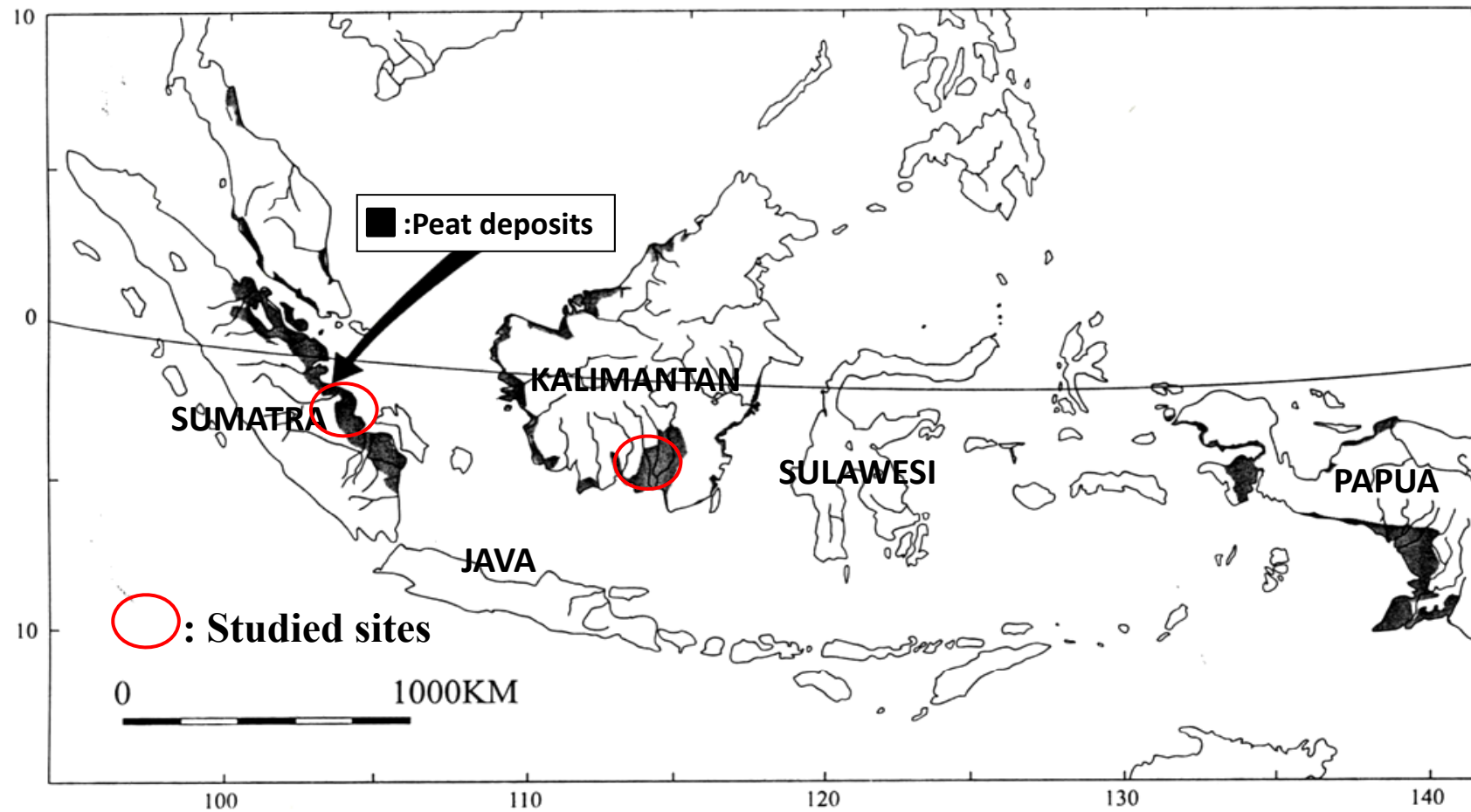
2. Methodology Employed

- ▶ The places of study were: (1) the eastern part of Jambi, Sumatra, and (2) the center and southern parts of Central Kalimantan
- ▶ The studied sites were placed in the representative areas: marine env. (1.0 - >2.0); brackish env. (0.5 – 1.0); and fresh water env. (<0.5 mmhos cm⁻¹).
- ▶ Research was divided into two steps:
 1. research that focused on the studies of peat properties, namely: chemical composition of peat (partition separation method); critical water content Bisdorn *et al.* [1993]; adsorption characteristic of Fe³⁺ based on the methods of Syers *et al.* [1973] and Fox and Kamprath [1971]; and measurement of C releases through the reduction-oxidation processes.
 2. field experiments: influence of the interaction of organic acids and mineral materials containing high Fe³⁺ on rice production and C-emission.



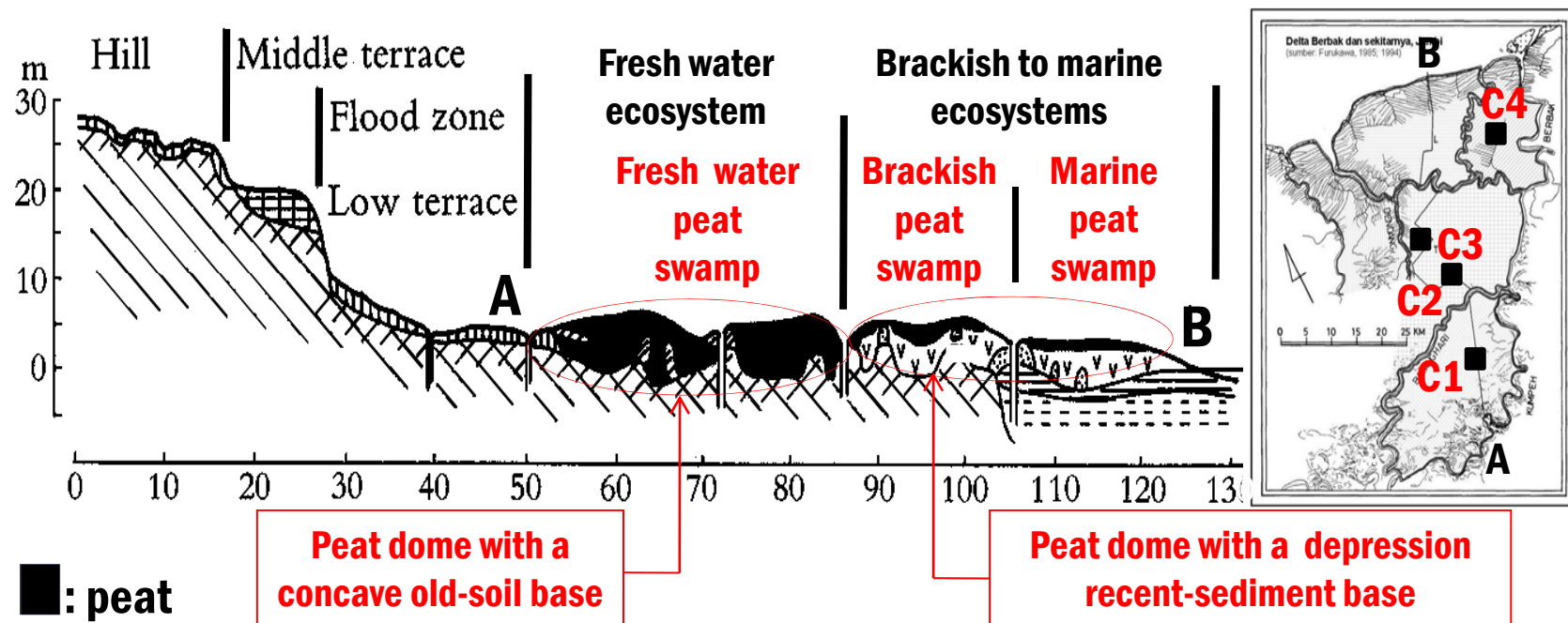
2.1.

Studied sites and peat distribution in Indonesia



2.2. Peat swamp ecosystems

Stratigraphy of peat deposits in Jambi as a model for the lower reach of the Indonesian peatland.
Modified from Supiandi [1988]



The oldest peat started to accumulate in 6850 year BP, and this is corresponding with the age of peat in the other sites [Anderson & Muller, 1975; Morley, 1981]

3. Peat properties & C-emission

- ▶ Recognizing the problems of peat, understanding of peat properties in relation to chemistry of C-emission seems to be more important.
- ▶ **The factors** which strongly affect chemistry of C-emission are as follow:
 1. Chemical composition of peat,
 2. Critical water content,
 3. Surface charge and adsorption characteristics of cation.
- ▶ **Low contents of water and cation** in peat is also a highest potential of C-losses.

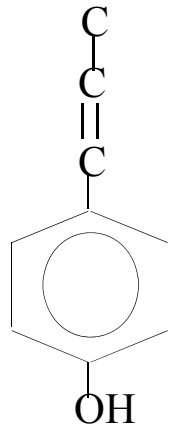


3.1.

Chemical composition of peat

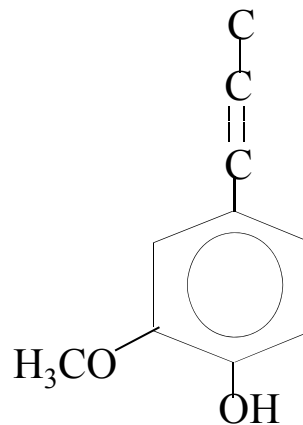
- ▶ Peat composition consists of: lignin, cellulose, hemi-cellulose, and protein.
- ▶ Lignin, as the dominant peat compositions, consists of 3-types of **basic monomers** derived from: (i) grasses or palm, (ii) soft wood, and (iii) hard wood

GRASS/PALM



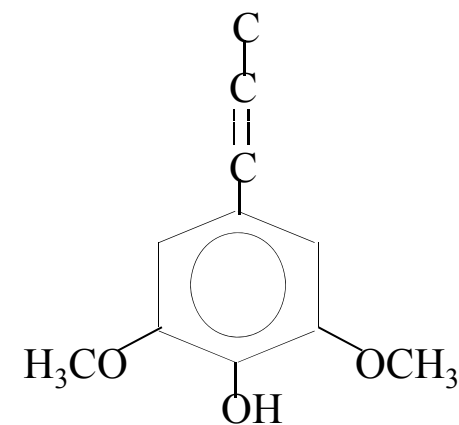
4-hydroxy phenyl
propane

SOFT WOOD



3-methoxy 4-hydroxy phenyl
propane

HARD WOOD

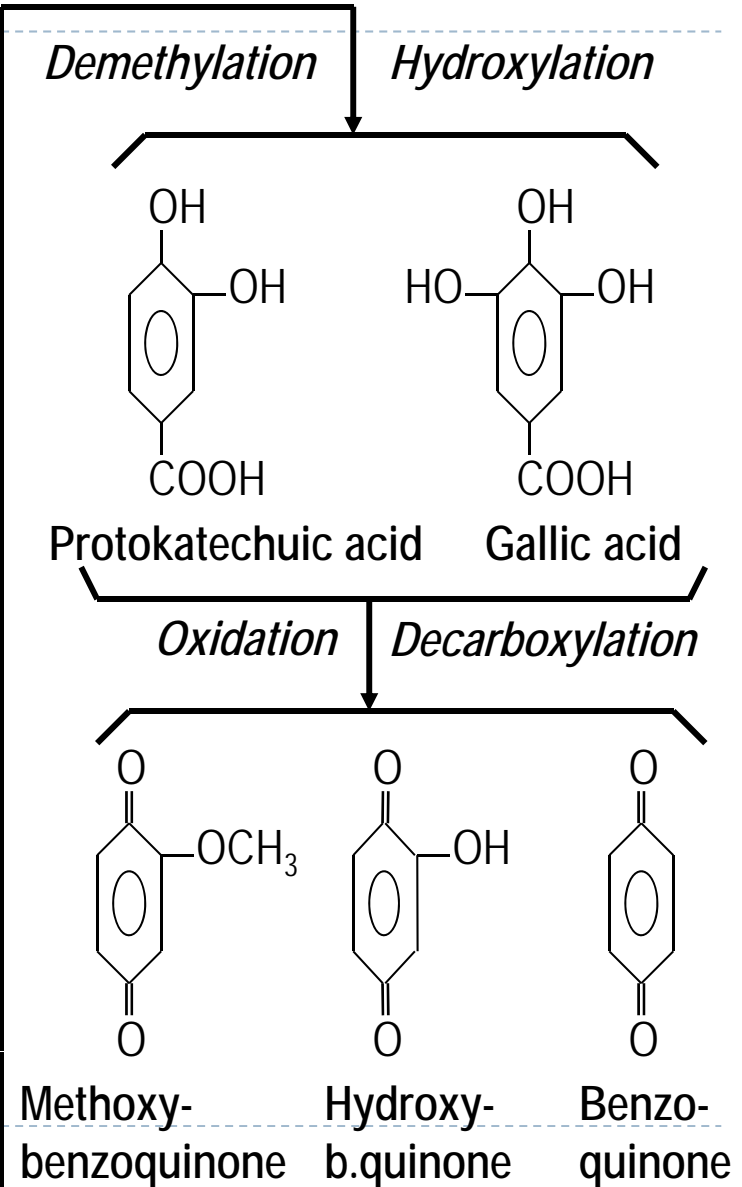
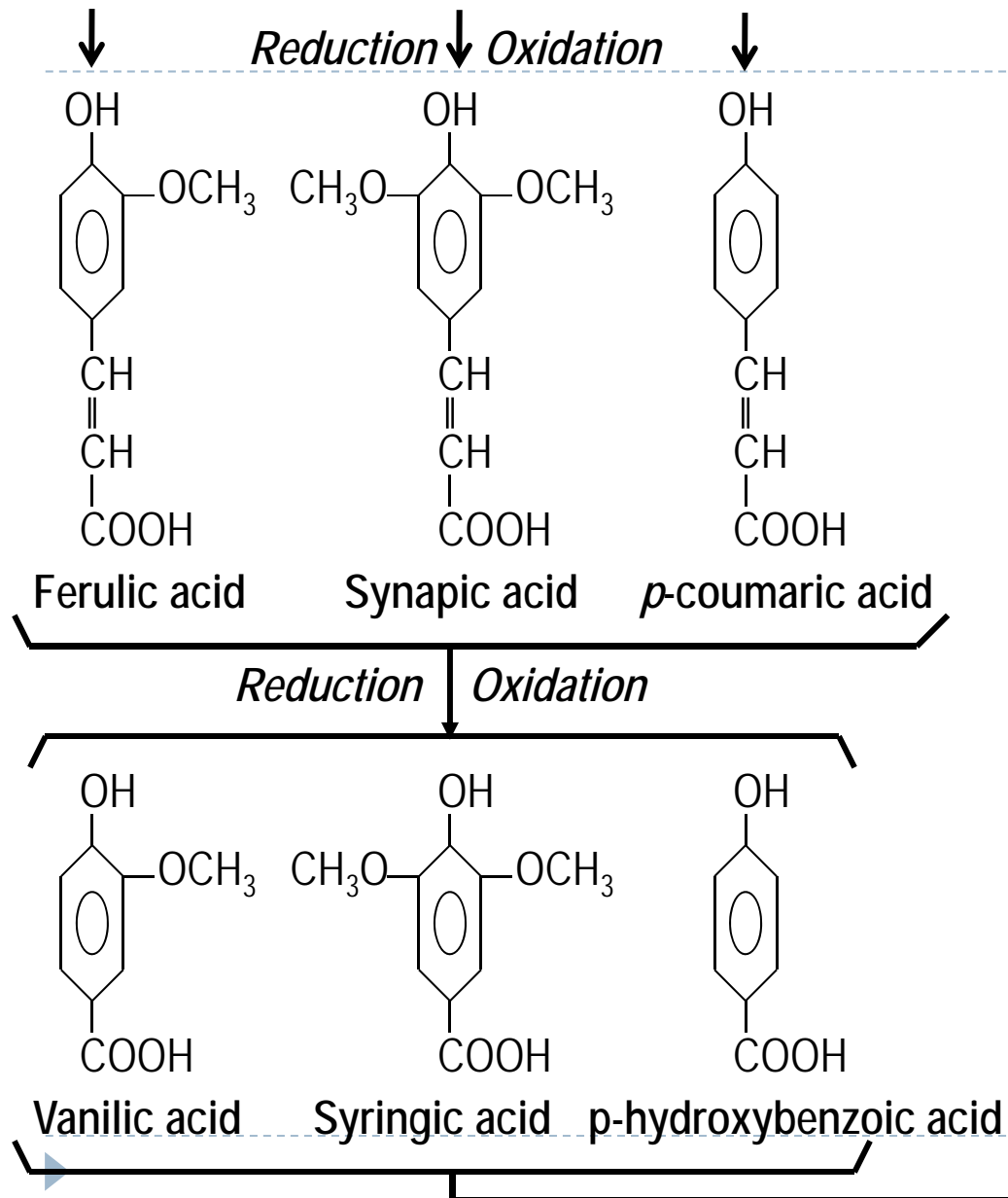


3-5-dimethoxy 4-hydroxy
phenyl propane



3.1.1. Lignin disintegration [Orlov, 1995]

SOFTWOOD HARDWOOD GRASS/PALM

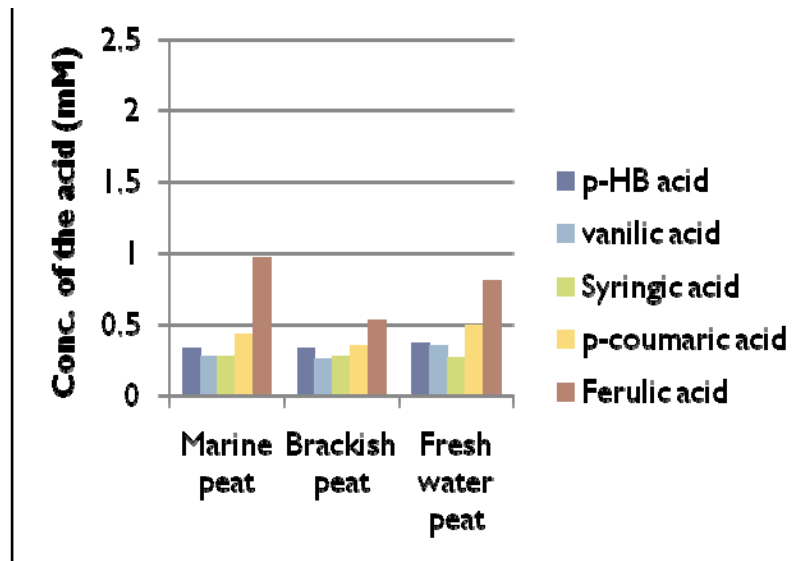


3.1.2.

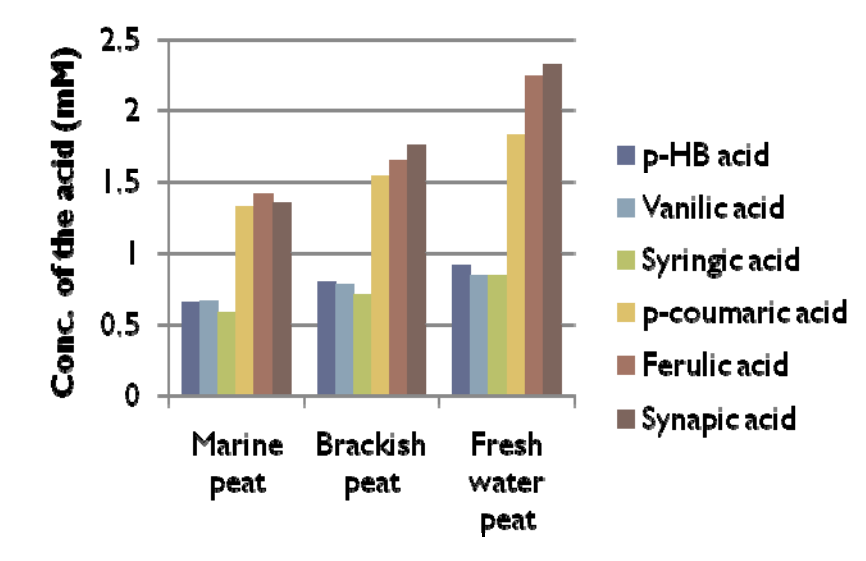
Concentration of “the most important” phenolic acids

Synapic acid \approx Ferulic acid > p-coumaric acid > p-hydroxybenzoic acid > vanilic acid > syringic acid

JAMBI, SUMATRA



CENTRAL KALIMANTAN

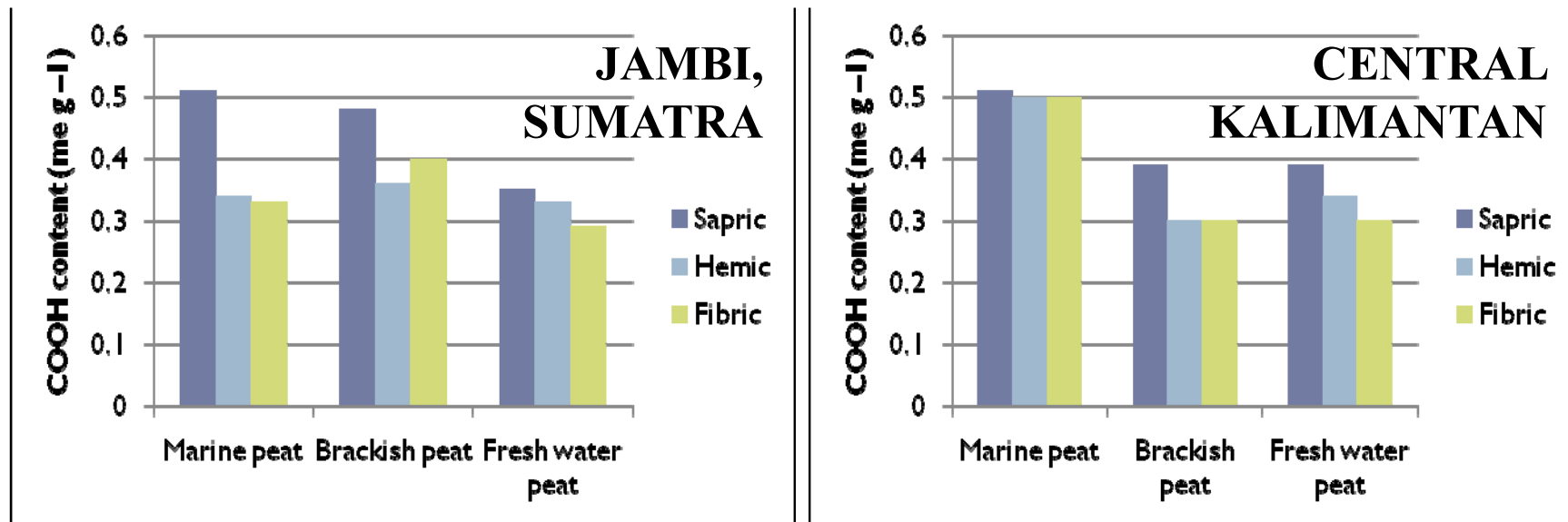


3.1.3.

COOH & methoxy groups and CO₂ & CH₄ releases

- ▶ Derivative phenolic acids were categorized as the main sources of C-release (in the forms of CO₂ and CH₄) **due to the high content of carboxyl (–COOH) and methoxy (–OCH₃) groups.**

The content of COOH in peat of Jambi, Sumatra and Central Kalimantan



3.1.3 (*continued*).

COOH & methoxy groups and CO₂ & CH₄ releases

- ▶ COOH could be broken down completely into CO₂ & H₂O through the processes of oxidation-reduction.

CO₂ could also be released when the methoxy groups (-OCH₃) changed into -OH groups during the phenol-OH formation through the processes of demethylation, hydroxylation and oxidation.



- ▶ A major pathway in anaerobic condition produce CH₄ through reduction of CO₂ with H₂ or organic molecules (H₂A) as the H donor if soil pH is very low, as follow:



3.2.

Critical water content and irreversible drying

- ▶ The most important factor that influenced COOH content in peat was of critical water content (CWC).

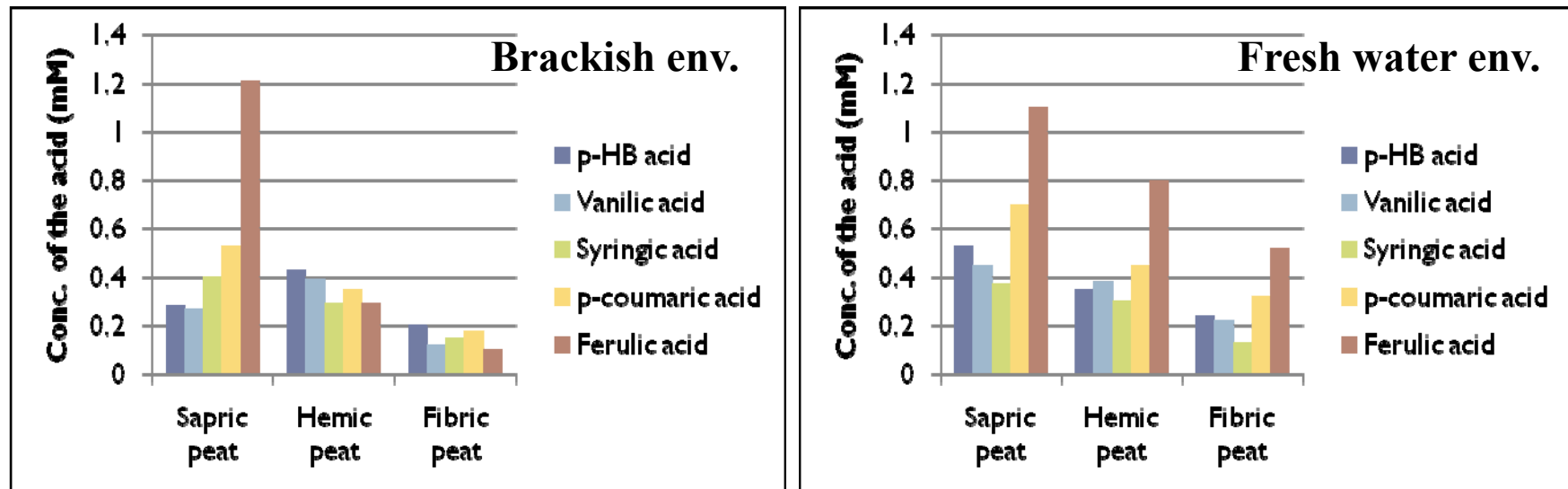
Peat Properties	Peat of Jambi			Peat of Central Kalimantan		
	Marine	Brackish	Fresh water	Marine	Brackish	Fresh water
FIBRIC PEAT						
ID period*	90	90	90	90	90	90
CWC (%)**	336.8–450.9	316.5–423.7	308.9–413.5	290.6–388.9	273.0–365.5	346.6–464.0
HEMIC PEAT						
ID period*	120	120	105	120	105	105
CWC (%)**	165.5–221.6	245.0–327.9	318.3–426.5	202.7–271.4	178.0–238.3	191.7–256.6
SAPRIC PEAT						
ID period*	135	105	120	135	135	120
CWC (%)**	165.5–221.6	245.0–327.9	318.3–426.5	202.7–271.4	178.0–238.3	191.7–256.6



3.2 (continued) .

Critical water content and irreversible drying

- ▶ Fibric peat needed a shorter period to reach the condition of irreversible drying compared with hemic and sapric peats.
- ▶ This is because, derivative phenolic acids as colloidal organics in fibric peat are lower than those in sapric and hamic peats, so the fibric peats could not much able to absorb more water.

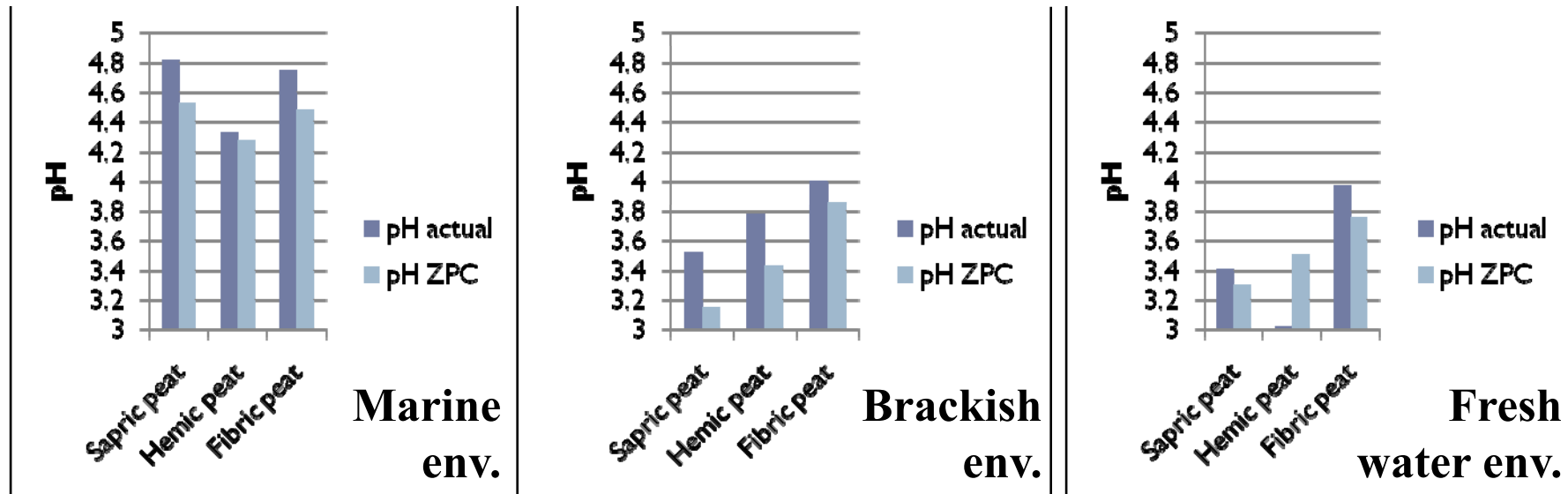


Concentration of derivative phenolic acids in peat of Jambi

3.3.

Surface charge and the adsorption characteristic of Fe^{3+}

- ▶ Based on pH actual and pH_{ZPC} , it can be mentioned that surface of colloidal organic of peats mostly indicated as negative charge.
- ▶ In acid condition, the charge is generally controlled by COOH groups; COOH started to dissociate its H^+ at pH 3–5.5.

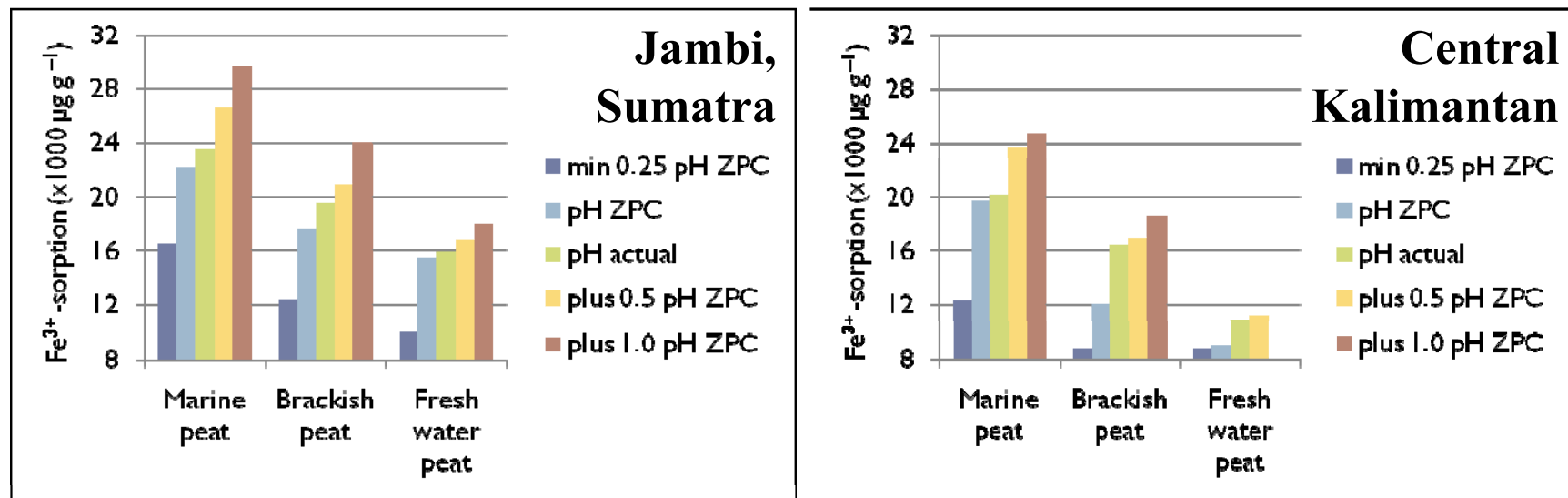
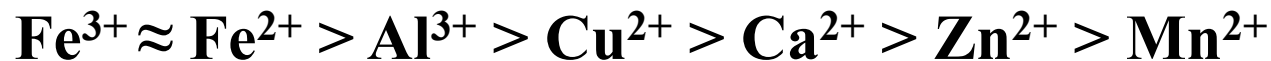


pH actual and pH_{ZPC} of Central Kalimantan's peats

3.3 (continued) .

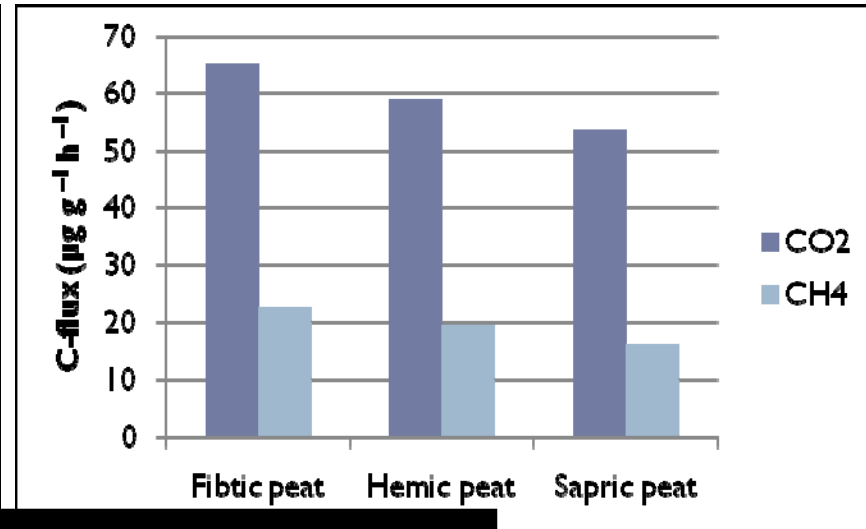
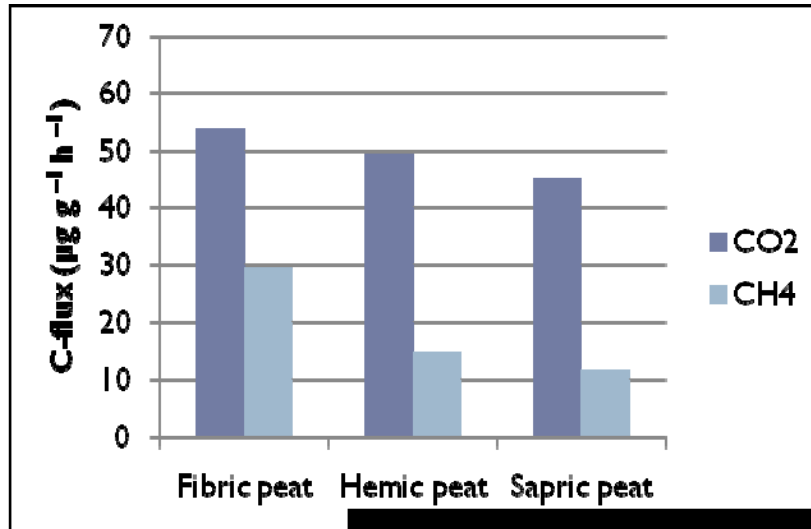
Surface charge and the adsorption characteristic of Fe^{3+}

- ▶ The presence of H^+ dissociation was very important for colloidal organic to adsorb cations, **which lead to complex reaction.**
- ▶ The series of cation listed in decreasing order of preferential interaction in the formation of complexes is as follows:

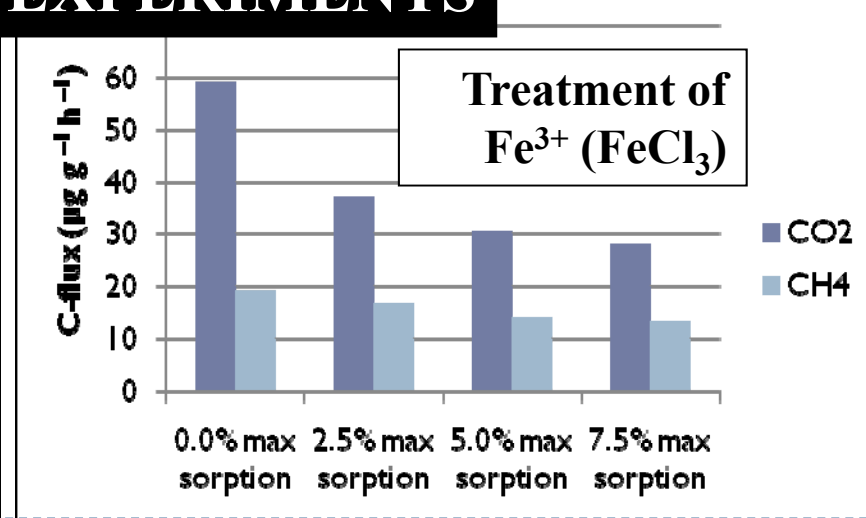
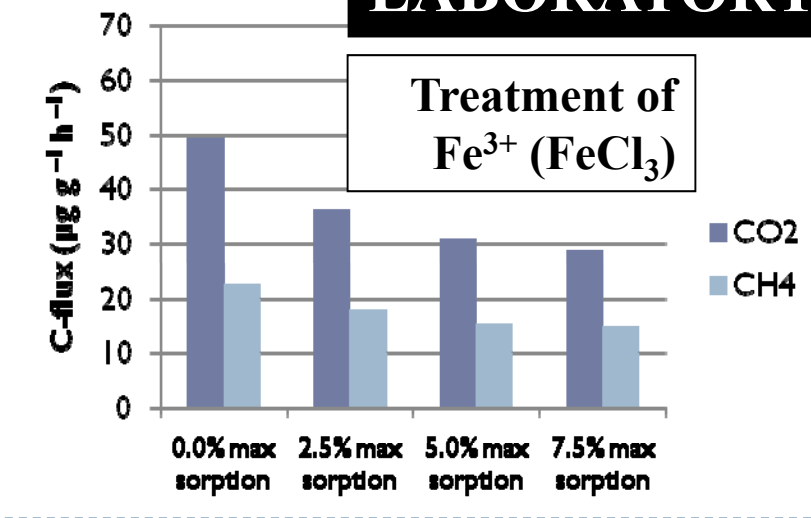


Fe adsorption by colloidal organic of peat

4. Measurement of CO₂ & CH₄ fluxes



LABORATORY EXPERIMENTS

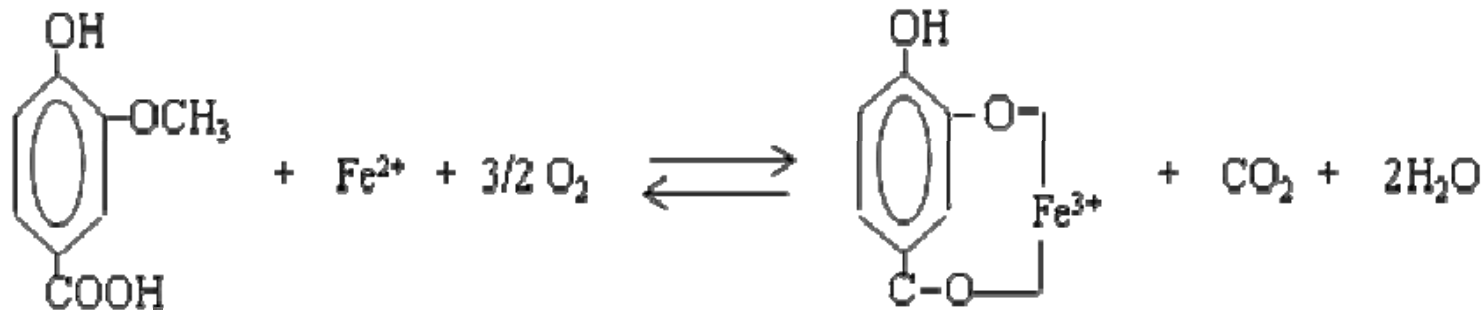


► Max. sorptions of Fe³⁺ in sapric, hemic and fibric peats re: 17346, 16509 and 13564 μg g⁻¹, respectively

4.1.

The decrease of CO₂ & CH₄ fluxes

- ▶ Treatment of 5.0% max. sorption of Fe³⁺ decreased CO₂ & CH₄ fluxes of about 37.5 to 48.4% and 26.9 to 33.0%, respectively, and it was chose for the treatment at field experiments.
- ▶ Although the treatment of 7.5% max. sorption could sharply decrease CO₂ & CH₄ fluxes, but Fe-solution is more higher than the treatment of 5.0%.
- ▶ The decrease is caused by the formation of stable complex binding as the illustration of the reaction as follow:



Vanillic acid

Complex reaction / chelation

5. Field Experiments

- ▶ Field experiments were focused on peats of Central Kalimantan: **Berengbengkel** (fresh water peat), **Sampit** (brackish peat) and **Samuda** (marine peat).

One of site experiments in Berengbengkel

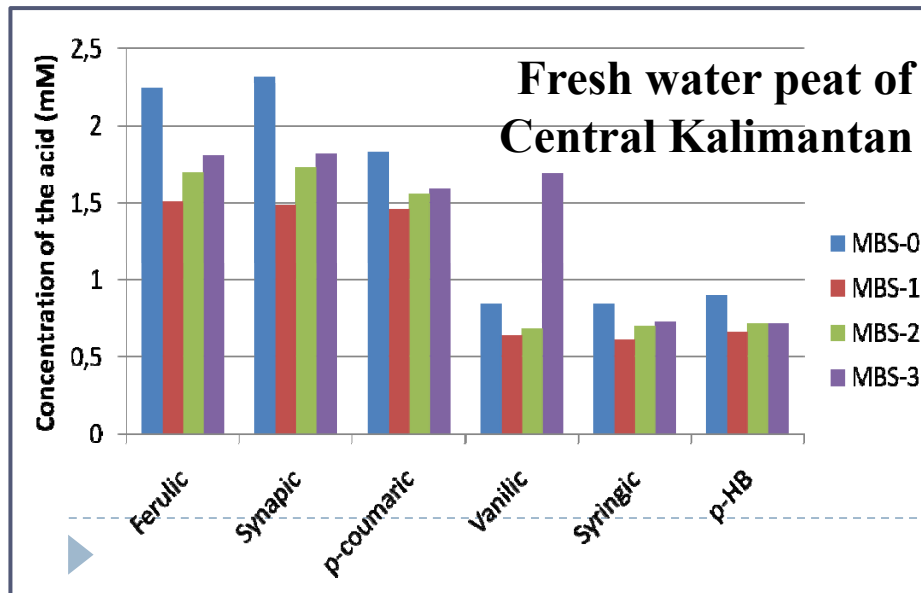
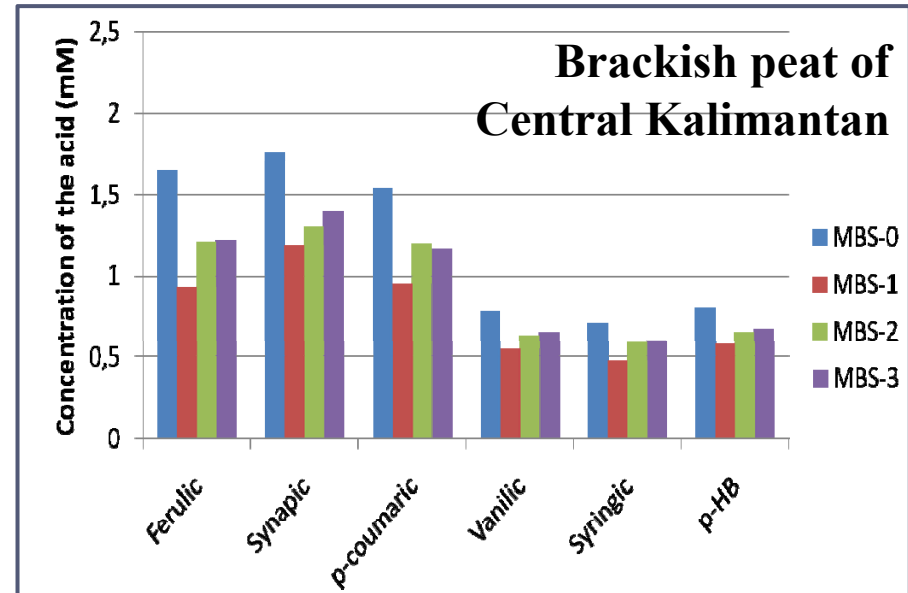
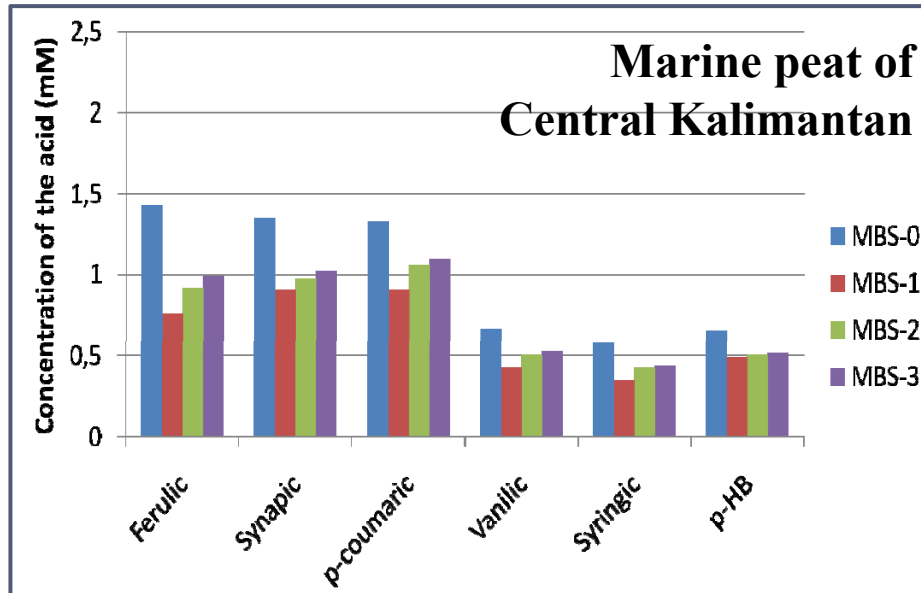


The site from which mineral soil as an ameliorant was taken



5.1.

Effect of M & BS treatments on derivative phenolic acids



The conc. of the acids decreased with the addition of mineral soil (M) or basic slag (BS), or the combination of them.

MBS₀ = without treatment (ameliorant).

MBS₁ = 100% M.

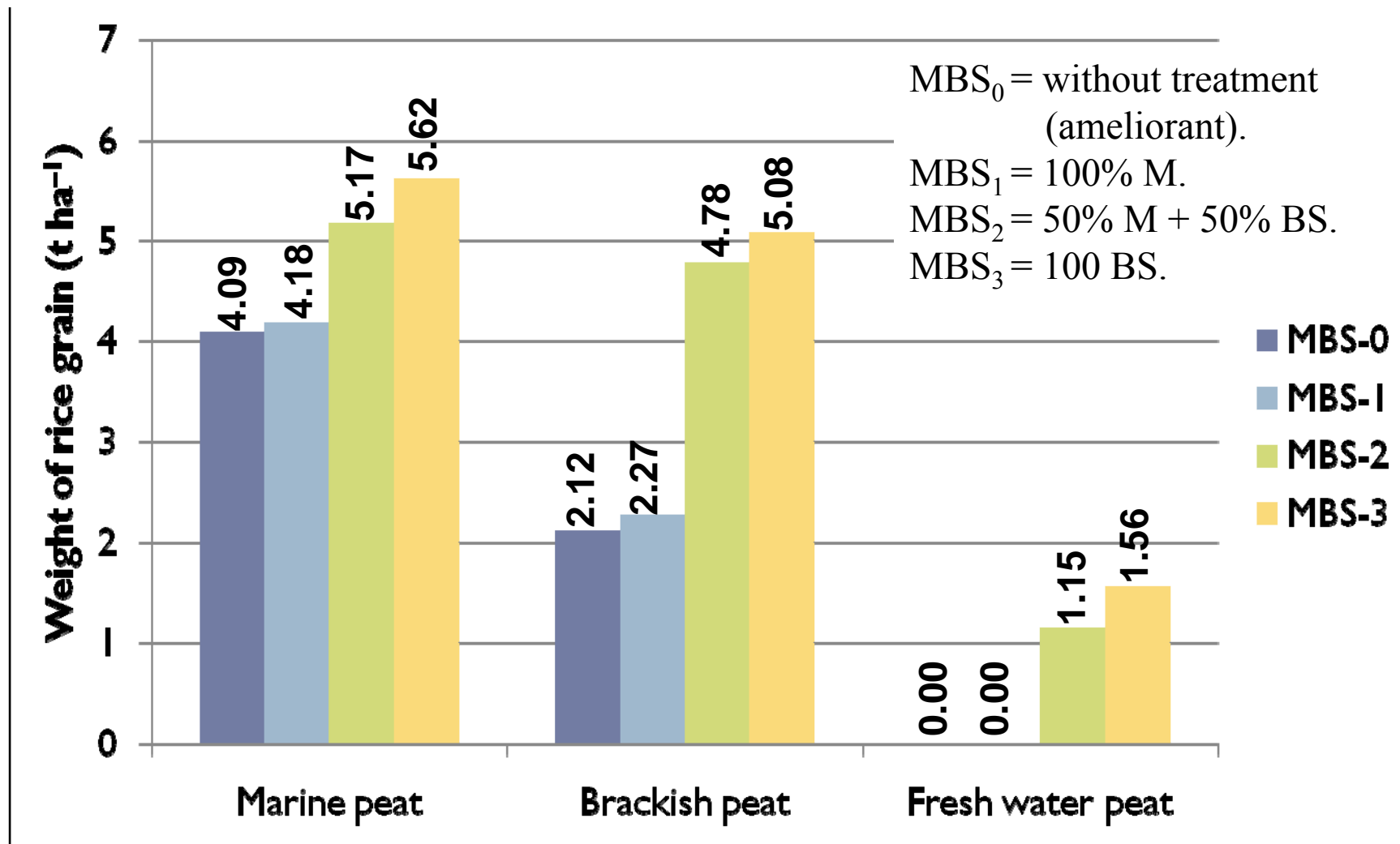
MBS₂ = 50% M + 50% BS.

MBS₃ = 100 BS.

The rate of M and BS is based on **5% max. sorption of Fe³⁺**.

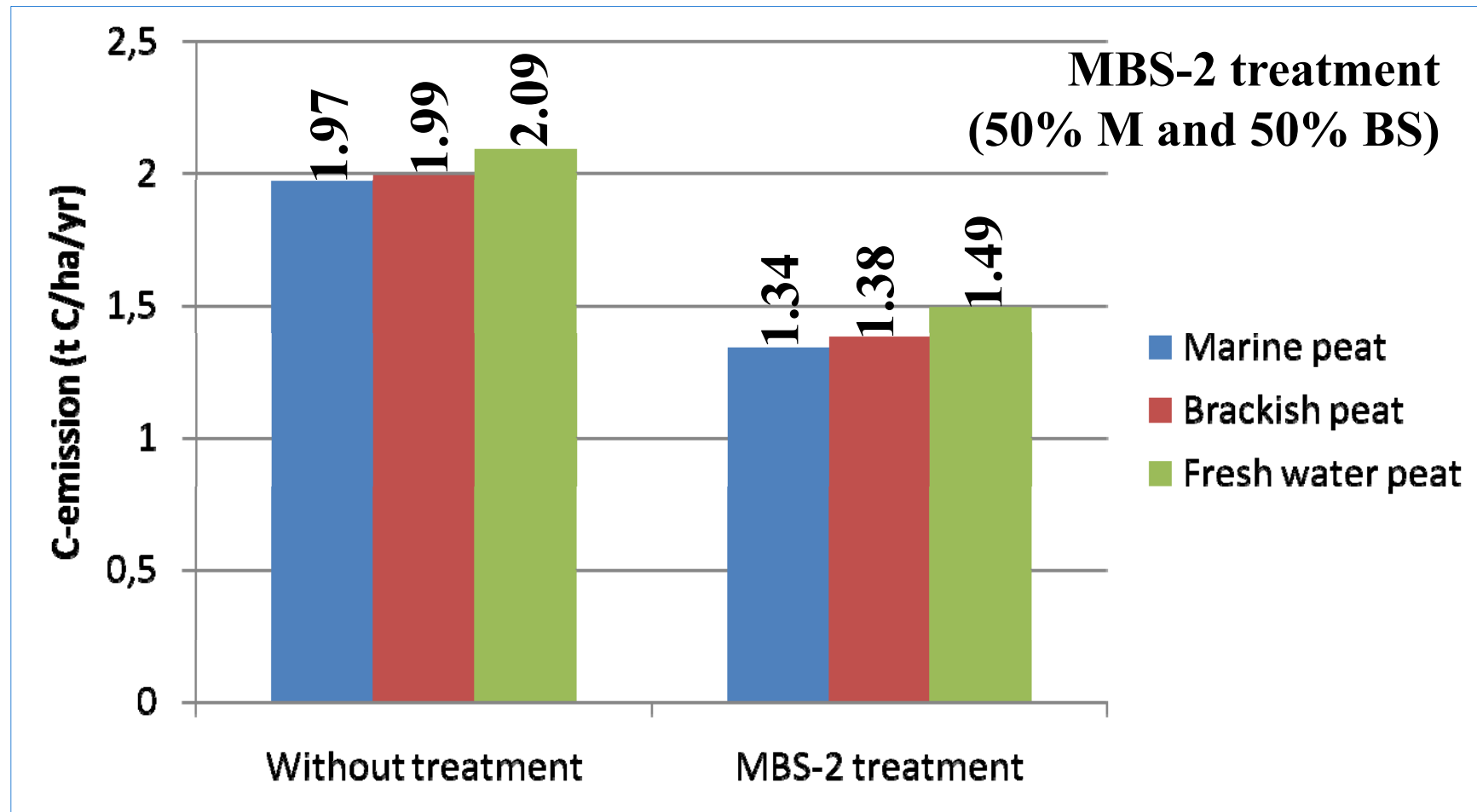
5.2.

Effect of treatments on rice production (IR-64)



5.3.

Effect of treatments on the average of C-emission



5. Conclusion

- ▶ Based on the properties of Indonesian peats, they were mostly easy to be destroyed due to low stability.
- ▶ The low stability was characterized by C-release in the form of CH_4 and CO_2 emissions as the results of decomposition process.
- ▶ To maintain the stability of peats, water content should always be kept higher than critical water content.
- ▶ By using ameliorants containing high Fe^{3+} , derivative phenolic acids as the sources of C-emission were decreased and peat productivity was increased.
- ▶ The decrease of C-emission was of $0.60 \text{ t C ha}^{-1} \text{ yr}^{-1}$ (28%) in fresh water peat, $0.61 \text{ t C ha}^{-1} \text{ yr}^{-1}$ (30%) in brackish peat, and $0.63 \text{ t C ha}^{-1} \text{ yr}^{-1}$ (31%) in marine peat.



6. Acknowledgment

- ▶ With the many problems I faced from the time I thought of implementing this research, I would not have been able to achieve any results without help from many side.
- ▶ For this reason I would like to sincerely thank Drs. Salampak, Muljady D. Mario, Siti Zahrah and Edwin S. Saragih, and Mr. Azri, Mr. Sulistyono and Mr. Nicolas for their assistance with field and laboratory works.
- ▶ This research was supported by the Team Research Grant Program, (URGE Project) Batch IV, Directorate General of Higher Education, Ministry of National Education, Indonesia.



**Field survey & research on peat swamp
forest in Lagan – Jambi [1976]**

