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# Microbial Enzyme Activities in Tropical Marsh Soils with Different Water Regime

Hojeong Kang, Seunghoon Lee
School of Civil and Environmental Engineering
Yonsei University
Seoul, Korea
hj_kang@yonsei.ac.kr

Jihyung Park
Dept. of Forest Environment Protection
Kangwon National University
Chuncheon, Korea
jihyungpark@kangwon.ac.kr

*Abstract*— **Tropical marsh ecosystems play a key role in global carbon cycle. Mineralization of organic matter mediated by enzymes in such systems is of great importance in the cycle but little is known about it. This study assessed a suite of enzyme activities in two depths of marsh soils with different water regime. Overall, enzyme activities were lower in drier soils than wet soils, suggesting water content would be a key controlling variable for decomposition in the system. Unlike northern peatland, decomposition rates may be lowered by frequent drought that is expected in the future climate.**

***Keywords-wetlands, extracellular enzymes, climate change, drought***

## I. INTRODUCTION

Tropical wetlands are one of the most important ecosystems in terms of global carbon dynamics. For example, tropical peatlands in Southeast Asia contain over 50 Gt of carbon as un-decomposed organic peat, which accounts for more than 10 % of total carbon stored in global peatlands. For this reason, a large number of studies have addressed carbon mineralization and trace gas fluxes such as CH4 or N2O from tropical peatlands. In particular, impacts of water level drawdown have been assessed widely because climate change models predict much lower precipitation in Asian tropical regions in the future. However, less efforts have been made to elucidate impacts of water level drawdown on tropical marsh systems, while marshes are another dominant wetland types in tropical regions.

Previous studies have reported mechanisms for accumulation of organic matter as peat is a result of extremely low decomposition in the system. Mechanism for such low decomposition rates was attributed to low temperature, water logging condition, low pH, and inhibitory effects of phenolics in northern peatlands where series of researches have been conducted by European and North American scientists. In particular, oxygen depletion caused by water logging conditions strongly inhibit phenol oxidase, which then results in accumulation of phenolics and inhibition of various hydrolase [1]. In contrast, little information is available about the mechanism of low decomposition in tropical peatlands. Further it is not confirmed that mechanism of phenol oxidase would function in marsh ecosystems where less amount of organic matter exist compared with peatland.

This study aims to determine microbial enzyme activities involved in organic matter decomposition in tropical marsh soils. In particular, we compare two locations with different water regime to address possible effects of water logging conditions.

## II. MATERIALS AND METHODS

Soil samples were collected from locations at a ‘Mandahan’ marsh area in Malaysia; One is flooded peat area covered with grass (N05° 34.32, E115° 53.53), and the other is drier edge of marsh covered with bushes (N05° 34.90, E115° 53.09). In each location, soil cores were collected from two depth; 0-5 cm and 5-10 cm. Five replicate samples were collected. Five different types of enzyme activities were determined. Phenol oxidase was measured using L-DOPA as a model substrate [2]. ß-glucosidase, chitinase, phosphatase and arylsulfatase activities were determined by employing methylumbelliferyl (MUF) compounds as model substrates [3]. Brifely, 1 g of soil samples were added with 4 mL of MUF substrate solution and incubated for an hour at 20° C. the reaction was terminated by centrifuging samples. Supernatant was transferred to a vial and fluorescence was determined by a TD-700 fluorometer with a 450 nm emission and 330 nm excitation wavelength. For each sample, a calibration curve was prepared using 0-200 µmol of MUF-free acid to account for quenching effects and soil absorption.

Other physical and chemical properties (water content, organic matter content, extractable phenolics, ammonium and nitrate) were also determined. Soil water content was measured by oven drying at 105 ° C and the organic matter contents were determined by loss-on-ignition at 600 ° C. Phenolic material was determined by a Folin reagent method. Ammonium was determined via indophenol blue method after extraction of soil with 2 M KCl. Nitrate was extracted with 0.5 M K2SO4 and measured by a colorimetric method.

Data were analyzed by 2-way ANOVA test to check whether effects of water regime, soil depth, and the interactions of the two were significant or not.

## III. RESULTS

### A. Enzyme activities

Overall enzyme activities were higher in water-logged soils than those in dry soils (Fig. 1). In water-logged soils, ß-glucosidase ranged from 4.67 – 7.38 nmol g-1 min-1, while that in dry soil varied between 1.13 and 2.13 nmol g-1 min-1. Likewise, chitinase in water-logged soils (11.66 – 16.23 nmol g-1 min-1) was much higher than in dry soils (2.81 – 7.07 nmol g-1 min-1).

Between surface and sub-surface soils, no significant differences were found in water-logged soils. However, sub-surface soil exhibited lower enzyme activities than surface soil in dry location (Fig. 1). Among different types of enzymes, chitinase activity was the highest, followed by phosphatase, ß-glucosdiase, arylsulfatase and phenol oxidase.

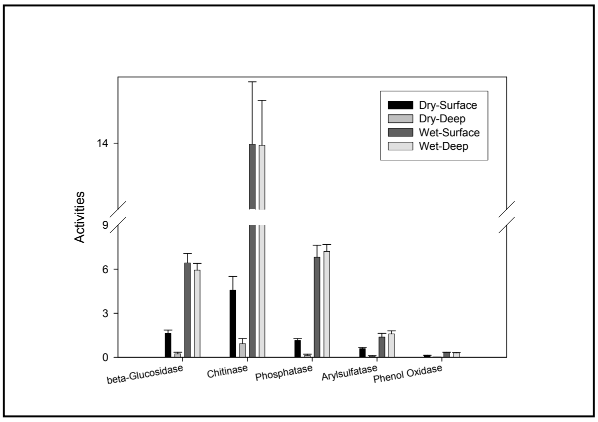


Figure 1. Enzyme activities in soils with different water regime and depth.

### B. Statistica analysis

Significant differences in chemical and enzyme data between two locations were found by a 2-way ANOVA (Table 1). However, no significant differences by soil depth or interactions of two factors were discernable, suggesting that only water regime is an important factor for enzyme activities and other chemical properties.

TABLE I. ANOVA TABLE FOR CHEMICAL AND ENZYME DATA.

| | Pheno-lics | Glucos idase | Chitina se | Phosph atase | Arylsu lfatase | Phenol Oxidas e |
|---|---|---|---|---|---|---|
| Water | 0.010 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Depth | 0.113 | 0.390 | 0.562 | 0.802 | 0.510 | 0.195 |
| W x D | 0.090 | 0.776 | 0.575 | 0.588 | 0.483 | 0.343 |

## IV. DISCUSSION

Overall results of this study indicate that water level drawdown may decrease decomposition rates in this system. This is contradictory to previous reports from northern peatland and temperate marshes where water level drawdown activates enzyme activities [4, 5]. Those studies have shown that long-term water-logged conditions would hinder transfer of oxygen to the system, which results in a decrease in phenol oxidase. This allows wetland to accumulate phenolics, which is a strong inhibitor of other hydrolase. This mechanism is called ‘enzyme latch hypothesis’, which is one of the most feasible mechanism for lower decomposition rates in water-logged conditions. However our system was not constrained by such ‘enzyme latch’ and hydrolase activities were activated by water supply.

The results of this study suggest that water supply may be limiting factor in our system, and hence drier location exhibited lower enzyme activities. One possible explanation for this is overall nutrient and organic matter availability. Wet location exhibited higher organic matter content because of higher primary production from wetland vegetation. In contrast, the drier edge soil is mainly sandy and poor in organic matter content. It has been widely noted that organic matter content is one of the key controlling variable for enzyme activities. Another possible mechanism is water supply. In tropical region, temperature is optimal for microbial proliferation. Water supply would limit microbial activities. Water content in wetter location was around 60% which is an optimal condition for microbial metabolism. In contrast, dry soils have around 30% of water content which may result in lower enzyme activities.

Unlike northern peatland or temperate marsh, tropical marsh we assessed may response differently to drier conditions that are expected to occur in the future climate. Longer-term observation along with manipulation experiment is warranted to confirm this observation. In addition, not only enzyme activities we assessed in this study, but also information about microbial abundance should be considered to better understand effects of water level changes in such system.

## ACKNOWLEDGMENT

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