UNIVERSITI PUTRA MALAYSIA

SPATIAL VARIABILITY OF SOIL MICROBIAL BIOMASS CARBON IN THE KUALA SELANGOR COASTLINE MANGROVES

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SPATIAL VARIABILITY OF SOIL MICROBIAL BIOMASS CARBON IN THE KUALA SELANGOR COASTLINE MANGROVES

BY

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A project submitted to the Faculty of Agriculture, Universiti Putra Malaysia, to fulfill the requirement of PRT4999 (Final Year Project) in order to be awarded the degree of Bachelor of Agricultural Science

Faculty of Agriculture

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2016/2017

CERTIFICATION

This project report entitled '**Spatial Variability of Soil Microbial Biomass Carbon in the Kuala Selangor Coastline Mangroves**' is prepared by Nik Nurul Shahira binti Nooh and submitted to the Faculty of Agriculture, to fulfill the requirement of PRT4999 (Final Year Project) in order to be awarded the degree of Bachelor of Agricultural Science.

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ABSTRACT

The rising levels of carbon dioxide (CO2) and other greenhouse gases is recognized as a serious environmental issue as it has caused global climate change. Mangrove forests are a part of a unique ecosystem that protects and stabilizes coastlines as well as mitigates the impact of climate change. Mangrove forests are also among the world's most productive ecosystems, producing organic carbon well in excess of the ecosystem requirements and contributing significantly to the global carbon cycle. Soil microbial biomass are fundamentally important in ecosystem function as its primary roles is in governing the many nutrient cycling reactions which are essential in the maintenance of soil fertility. As such, the biomass is both a source and sink of the nutrients carbon, nitrogen, phosphorus and sulphur (C, N, P and S) contained in the organic matter. This study is aimed at determining the spatial variability map of soil microbial biomass C in the mangrove stands. 40 quadrant within the area of 80 m x10 m was formed. Soil samples at different depth which is 0-15 cm and 15-30 cm was taken to analyse for soil microbial biomass C. Geospatial analysis and spatial variability mapping was performed on each test variable.

ABSTRAK

Peningkatan tahap karbon dioksida (CO_2) dan gas rumah hijau yang lain telah dikenalpasti sebagai isu alam sekitar yang sangat serius kerana ia telah menyebabkan perubahan pada iklim global. Hutan bakau adalah sebahagian daripada ekosistem yang unik yang melindungi dan menstabilkan pantai serta mengurangkan kesan perubahan iklim. Hutan bakau juga merupakan antara ekosistem yang paling produktif di dunia, menghasilkan karbon organik jauh melebihi keperluan ekosistem dan menyumbang dengan ketara kepada kitaran karbon global. Tanah mikrob biomas adalah asas penting dalam fungsi ekosistem sebagai peranan utamanya adalah dalam mentadbir banyak reaksi kitaran nutrien yang penting dalam mengekalkan kesuburan tanah. Oleh itu, biomas adalah kedua-dua sumber dan tenggelam nutrien carbon, nitrogen, phophorus dan sulfur (C, N, P dan S) yang terkandung dalam bahan organik. Kajian ini bertujuan untuk menentukan peta kepelbagaian mikrob tanah biomas C di kawasan pokok bakau. 40 kuadran dalam kawasan 80 m x10 m telah ditubuhkan. Sampel tanah pada kedalaman yang berbeza iaitu 0-15 cm dan 15-30 cm telah diambil untuk menganalisis mikrob tanah biomass C. Geospatial dan pemetaan kepelbagaian dilakukan pada setiap pembolehubah ujian.

CHAPTER 1

INTRODUCTION

Climate change is one of the greatest challenges of our time. The increase of carbon dioxide concentration has apparently triggered the global temperature rise, which cause a great deal of discomfort to the world population. Mangrove forest becomes the crucial factor in mitigating the climate change impact as well as in protecting the coastlines. Mangroves consist of plant communities commonly found between the lowest and the highest tide level. These plants had evolved over time by developing special adaptive features allowing them to better survive in a harsh and stressful environment (Mastaller, 1997). However, this unique ecosystem is under tremendous stress due to erosion, excessive anthropogenic activities and natural disasters such as tsunamis. The coastlines of Malaysia have witnessed a drastic decline in the recent years whereby 29% of the Malaysian coastal areas were reported to be vulnerable to serious erosion. (Wan Rasidah et al., 2015).

Salinity plays an important role in the growth and survival of mangroves. But, salinity also affects the microbial population in the estuaries that usually controls the biogeochemical cycles and transformation of most nutrients in the mangrove. Microbial biomass such as bacteria are the largest contributors to carbon flux in these sediments. Most microbes assist as primary decomposers of organic residues and are fundamental for the carbon cycle and nutrient availability to the vegetation species. Quantification and management of microbial biomass carbon (MBC) in a regional scale would involve the deployment of cutting edge geo-spatial technologies, which are routinely used in Precision Agriculture (PA).

Spatial variability is an important tool as it can lead to site-specific ecosystem management which allows for resource optimization (Balasundram et al., 2008). The scarce information and knowledge about the management of the microbial biomass have led to a research and development in rehabilitation and conservation efforts of the mangrove forest. To replace the conventional techniques, the present tools which are geospatial statistic can be used for the quantification and mapping as well as monitoring the carbon sequestration. Developing spatialized maps for soil MBC would be an important assessment which will actually elucidate the threshold levels of the microbial biome toward salinity.

1.1 Problem Statement and Hypothesis

The coastline mangroves in Sungai Besar are exposed to the changing of tidal intensity which can alter the soil physicochemical properties. Increasing soil salinity showed negative effect on the microbial biomass carbon.

1.2 Objectives

1) To determine the spatial variability of soil microbial biomass C in the mangrove stands of Sungai Besar, Kuala Selangor

REFERENCES

Vijayanathan, J., Balasundram, S. K., Hanif, M., & Husni, A. (2011). Geo-spatial technologies for carbon sequestration monitoring and management. American Journal of Environmental Sciences, 7(5), 456-462.

Wah, L. M., Mojiol, A. R., & Saleh, E. (2011). Diversity of mangroves ecosystem in Semporna mangrove forest. Borneo Sci, 28(8), 17.

Jeyanny, V., Balasundram, S. K., Husni, M. H. A., Rasidah, K. W., & Arifin, A. (2013). Spatial variability of selected forest soil properties related to carbon management in tropical lowland and montane forests. Journal of Tropical Forest Science, 577-591.

Abd. Shukor, A.H. (2004). The use of mangroves in Malaysia. In: Promotion of mangrove-friendly shrimp aquaculture in Southeast Asia (pp. 136-144). Tigbauan, Iloilo, Philippines: Aquaculture Department, Southeast Asian Fisheries Development Center.

McKee, K. L. (2002). Mangrove ecosystems: definitions, distribution, zonation, forest structure, trophic structure and ecological significance. In Mangrove ecology workshop manual (pp. 1-6). ^ eWashington, DC Washington, DC: Smithsonian Institution Press.

Kathiresan, K., & Bingham, B. L. (2001). Biology of mangroves and mangrove ecosystems. Advances in marine biology, 40, 81-251.

Chapman, V. J. (1976). Mangrove vegetation. J. Crammer, Vaduz, Germany.

Jose, S., & Bardhan, S. (2012). Agroforestry for biomass production and carbon sequestration: an overview. Agroforestry Systems, 86(2), 105-111.

Rahman, M. M., Khan, M. N. I., Hoque, A. F., & Ahmed, I. (2015). Carbon stock in the Sundarbans mangrove forest: spatial variations in vegetation types and salinity zones. Wetlands Ecology and Management, 23(2), 269-283.

Lovelock, C. E., Adame, M. F., Bennion, V., Hayes, M., O'Mara, J., Reef, R., & Santini, N. S. (2014). Contemporary rates of carbon sequestration through vertical accretion of sediments in mangrove forests and saltmarshes of South East Queensland, Australia. Estuaries and coasts, 37(3), 763-771.

Rehman, A. U., Ullah, W., & Khurshid, M. (2014). Developing carbon sequestration model for Indonesian peat swamp forest using soil and biomass carbon stock as proxy: options and opportunities for peatland mapping and carbon trading in Indonesia. International Journal of Current Research and Review, 6(10), 1.

Kumar, B. M., & Nair, P. R. (Eds.). (2011). Carbon sequestration potential of agroforestry systems: opportunities and challenges (Vol. 8). Springer Science & Business Media.

Vance, E. D., Brookes, P. C., & Jenkinson, D. S. (1987). An extraction method for measuring soil microbial biomass C. Soil biology and Biochemistry, 19(6), 703-707.

Ley, R.E., D.A. Lipson and S.K. Schmidt. 2001. Microbial biomass levels in barren and vegetated high altitude talus soils. Soil Sci. Soc. Am. J. 65:111–117.

Follett, R.F. and D.S. Schimel. 1989. Effect of tillage practices on microbial biomass dynamics. Soil Sci. Soc. Am. J. 53:1091-1096.

Cemek, B., GÜLer, M., KiliÇ, K., Demir, Y., & Arslan, H. (2007). Assessment of spatial variability in some soil properties as related to soil salinity and alkalinity in Bafra plain in northern Turkey. Environmental monitoring and assessment, 124(1-3), 223-234.

Wang, G., Guan, D., Zhang, Q., Peart, M. R., Chen, Y., Peng, Y., & Ling, X. (2014). Spatial patterns of biomass and soil attributes in an estuarine mangrove forest (Yingluo Bay, South China). European Journal of Forest Research, 133(6), 993-1005.

Osborne, T. Z., Bruland, G. L., Newman, S., Reddy, K. R., & Grunwald, S. (2011). Spatial distributions and eco-partitioning of soil biogeochemical properties in the Everglades National Park. Environmental monitoring and assessment, 183(1-4), 395-408.

Balasundram, S. K., Robert, P. C., Mulla, D. J., & Allan, D. L. (2006). Spatial variability of soil fertility variables influencing yield in oil palm (Elaeis guineensis Jacq.). Asian Journal of Plant Sciences, 5(2), 397-408.

1997 Precision agriculture: spatial and temporal variability of environmental quality. Wiley, Chichester (Ciba Foundation Symposium 210) p18-37

Zheng Y-M, Chen T-B, He J-Z (2008): Multivariate Geostatistical Analysis of Heavy Metal in Topsoils from Beijing, Chinia. J Soils Sediments 8 (1) 51–58

Nowak, W. (2010). Measures of parameter uncertainty in geostatistical estimation and geostatistical optimal design. Mathematical Geosciences, 42(2), 199-221.

Oliver, M. A. (Ed.). (2010). *Geostatistical applications for precision agriculture*. Springer Science & Business Media.

Nutter, F. W., Emmanuel Z. Byamukama, Rosalee A. Coelho-Netto, Sharon K. Eggenberger, Gleason, M. L., , A. G., Alison E. Robertson & Rij, N. V. 2011. Integrating GPS, GIS,and remote sensing technologies with disease management principles to improve plant health. In: Clay, S. (ed.) GIS applications in agriculture. Boca Raton-USA: CRC Press.

Sherman, M. 2011. Spatial statistics and spatio-temporal data: covariance functions and directional properties, USA, John Wiley & Sons.

Shahbazi, F., Aliasgharzad, N., Ebrahimzad, S. & Najafi, N. 2013. Geostatistical analysis for predicting soil biological maps under different scenarios of land use. European Journal of Soil Biology, 55, 20-27.

Pati, F. M., Clay, D. E. & Carlson, G. 2011. Nutrient management for improved energy efficiency. In: Clay, D. E. & Shanahan, J. F. (eds.) GIS applications in agriculture, nutrient management for energy efficiency. Boca Raton-USA: CRC Press.

Vance, E. D., Brookes, P. C., & Jenkinson, D. S. (1987). An extraction method for measuring soil microbial biomass C. Soil biology and Biochemistry, 19(6), 703-707.

Sparling, G. P., Pankhurst, C., Doube, B. M., & Gupta, V. V. S. R. (1997). Soil microbial biomass, activity and nutrient cycling as indicators of soil health. Biological indicators of soil health., 97-119.

Joergensen, R. G. (1996). The fumigation-extraction method to estimate soil microbial biomass: calibration of the k EC value. Soil Biology and Biochemistry, 28(1), 25-31.

Wolf, P. R., & Dewitt, B. A. (2000). Elements of Photogrammetry: with applications in GIS (Vol. 3). New York: McGraw-Hill.

Ukpong, I. E. (1994). Soil-vegetation interrelationships of mangrove swamps as revealed by multivariate analyses. Geoderma, 64(1-2), 167-181.

Clarke, L. D., & Hannon, N. J. (1967). The mangrove swamp and salt marsh communities of the Sydney district: I. Vegetation, soils and climate. The Journal of Ecology, 753-771.