ISBN : 978-979-8389-18-4

PROSIDING

SEMINAR NASIONAL DAN RAPAT TAHUNAN DEKAN

Bidang Ilmu-Ilmu Pertanian
Badan Kerjasama Perguruan Tinggi Negeri
(BKS-PTN) Wilayah Barat

VOLUME II

TEMA :
PERAN IPTEK UNTUK MENGANTISIPASI PERUBAHAN IKLIM
DALAM PERSPEKTIF PERTANIAN BERKELANJUTAN

FAKULTAS PERTANIAN
UNIVERSITAS SRIWIJAYA

PALEMBANG, 23 - 25 MEI 2011

Prosiding Semirata
Bidang Ilmu-Ilmu Pertanian BKS-PTN Wilayah Barat Tahun 2011
ISBN: 978-979-8389-18-4

Impact of Land Use Change on Organic Matter Content and Physical Properties of Soil in Bukik Pinang-Pinang under Tropical Rainforest, Mount Gadut West Sumatra

Yulnafatmawita*), Hermansah, and Amrizal Saidi
Soil Physics and Conservation Laboratory, Andalas University
*)*Email: ita_lamsoeddin@yahoo.com*

ABSTRACT

(*A study about soil organic matter variation and soil physical properties as affected by land use change had been conducted in in Bukik Pinang-Pinang, tropical rain forest area. The area is located approximately 30 km from Padang city (100°29'40"-100°30'20" E and 0°54'55"-0°55'45" S), with altitude 380-640 m asl. This area is known as the wettest part in Indonesia, even in the world, due to its high annual rainfall which is up to 6500 mm/y. The water flows down to Padang city through Batang Kuranji, one of the biggest rivers passing the city. Bukik Pinang-Pinang and the surroundings function as hydrology regulator for the down environment, therefore it must be well-managed. The objective of the research was to determine soil organic matter content and physical properties at three different types of land use in Bukik Pinang-Pinang. Soil organic matter content of non-forest land use (mixed trees and bush land) tended to be higher than forest ecosystem. Furthermore, soil texture on the forest and bush land was finer than on the mixed perennial trees. Bulk density and total porosity of the soil was categorized as medium, and permeability was considered as fast for each land use.*)

Keywords : *Rain forest, land use change, soil organic matter content, soil physical properties*

INTRODUCTION

Land use change has intensively happened lately in developing countries. The changing is not only limited to urban areas, but also to rural areas, even in remote areas which is considered as conservational region. The changing can be from farming land to non-agricultural purposes or from virgin ecosystems (forest) to cultivated land or even bare land. The last is conducted illegally which often happens in remote areas, aiming to cut the wood without replanting it, such as in Bukik Pinang-Pinang area. Based on Agus (2005) intensive land use change in Indonesia has been started since last few decades. Therefore, fertile agricultural land continuously reduced by years. As reported by Irianto (2004) that around 22,000 ha rice field in Java island was conversed during 1987 – 1993. Even, it has reached 100,000 ha of rice field that had been conversed by the end of year 2000.

Bukik Pinang-Pinang is located approximately 30 km from Padang city (100°29'40"-100°30'20" E and 0°54'55"-0°55'45" S), on altitude 480-640 m *asl*. This area is known as the wettest part in Indonesia, even in the world. It receives up to 6500 mm/y (Rasyidin, 1994). In climate classification, this area is grouped into *Afa – Ama* type based on Koppen, and zone A based on Oldeman (Ogiono, 1984). Therefore, it is called as super wet tropical rain forest. The water collected on the area flows down to Padang city through Batang Arau, one of the biggest rivers passing the city. Since Bukik Pinang-Pinang is located on the higher altitude, the area and the surroundings function as hydrology regulator for the downward environment, especially Padang city, the capital of West Sumatra. Therefore, it must be well-managed to avoid natural disaster, such as flood and land slide during rainy season as well as drought during dry season, which threats our sustainable environment.

In fact, since last few decades, some of the primary forest had been started to cut. Then, some part of the cleared area was planted with mixed perennial trees (Durian,

Manggis, Cinnamon, Cacao, Duku) and some was abandon and grown by bush. Whether the condition changed the organic matter content and the soil physical properties of the soil or not was interested to know. Soil organic matter content and physical property determination are important as a data base for finding out the best management applied to the land. The objective of the research was to determine soil organic matter content and soil physical properties at three different land uses in Bukik Pinang-Pinang.

MATERIALS AND METHODS

Survey method was employed for this research, and the soil was randomly sampled in each land use (purposively random sampling) on 0-20 and 20-40 cm depth. Three types of land use in the area were primary forest (on the top, ± 635-640 m *asl*, 10° slope, and on the middle, ± 570-585 m *asl*, 18-22° slope), bush land (± 590-600 m *asl*, 4-22° slope), and mixed perennial trees (± 390-398 m *asl* with ± 8° slope). Satellite soil samples were taken for soil texture (sieve and pipette method), soil organic matter (Walkley and Black method), then undisturbed soil samples for permeability (constant head method based on Darcy's law), bulk density and total porosity (gravimetric method). Soil samples were dried and analysed in soil science laboratory, Andalas University. Data from the analyses were compared to criteria of soil characteristics.

RESULT AND DISCUSION

A. Soil Organic Matter Content (SOM)

Land use change from forest into bush land and mixed perennial trees did not decrease the SOM content, even it increased at foot slope (Fig. 1). Higher SOM content under mixed perennial trees at foot slope was possibly due to the function of the under storey plants covering the soil surface permanently. People planting the trees never cleared the surface as well as cultivated the soil. Since the sunlight reached the soil surface, the OM derived from the under storey plants was decomposed faster and contributed to SOM. A part from that, the permanently planted area with perennial trees for a long time had stabilized the environment as it almost reached a forest ecosystem. Therefore, forest area after being or cleared must be replanted in order to reach the same environment to the forest again, in order to keep sustainable environment.

Under forest ecosystem, otherwise, the SOM derived from trees was accumulated on the soil surface up to 10 cm high. It was slowly decomposed due to high moisture and low temperature on the soil surface. Different weather condition under primary forest was caused by the effect of plant canopy which is quite dense that limit the sunlight to reach the soil surface. Then, low sunlight means low evaporation. Since the area has high

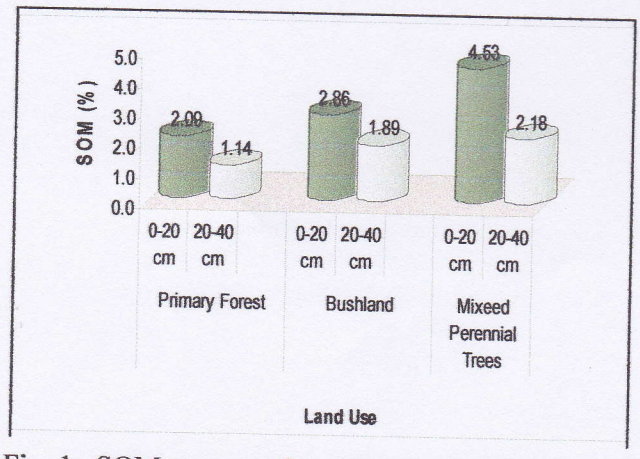

Fig. 1. SOM content of soils in Bukik Pinang-Pinang

rainfall annually, low evaporation keeps the soil surface quiet humid. Therefore, as the consequence of the condition, the organic matter decomposers worked slower. As found by Yulnafatmawita et al., (2003) that land use change from forest into pasture for about 100 years in rainforest area in Queensland Australia did not show significant different of the SOM content on the top 0-20 cm depth. In adjacent site to Bukik Pinang-Pinang, that is Bukik Gajabuih, the SOM content of the primary forest was lower than that in bush land and mixed perennial tree types of land use (Yulnafatmawita, et al., 2007).

Furthermore, from Figure 3 also showed that SOM content of the soil decreased from the top 20 cm depth into 20-40 cm depth for each land use. As soil organic matter source was primarily from above ground, the organic matter content of the soil decreased by lower depth within soil profile. It was also found to be true in Bukik Gajabuih for each land use (Yulnafatmawita, et al., 2007), the SOM content decrease at deeper soil layer. Higher amount of SOM content in soil profile is really expected to increase organic carbon sequestration or to decrease carbon content (CO2 concentration) in atmosphere. Carbon dioxide was one of the greenhouse gas which gives the highest contribution to global warming (AGO, 2002).

B. Soil Physical Properties

1. Particle Soil Distribution and Soil Texture

As shown in Figure 2, soil on the top or higher slope area, under primary forest ecosystem, was dominated by fine particles (clay). The lower the altitude tended to be the coarser the soil particles. The soil under mixed perennial trees (on foot slope) was dominated by silt. The soil texture on the top forest as well as under bush land on the middle slope was classified into clay, while on the foot slope was loam (based on texture triangle by USDA). The difference in soil texture among the land use much depends on the parent materials. Based on Wakatsuki *et al.* (1986) the soil on this area was still newly developed (order Inceptisols), with suborder *Lithic Dystropept, Lithic Eutropept*, and *Typic Dystropept* on the top. While on the foot slope, soil texture was much affected by the river (Batang Lantiak) passing through the area.

The area on the foot slope having coarse soil texture had high infiltration rate compared to the other two types of land use (Yulnafatmawita, et al., 2009). High infiltration means low runoff, and high chance of SOM to get into deeper soil profile and sequestered in soil, as a consequent, low possibility of erosion. Then, the function of the area as a regulator for hydrology can be maintained.

The pattern of soil particle size distribution on upper soil profile was also found o n the lower layer. For primary forest and food land, the particles of the soil were dominated by clay. Clay content for each land use tended to increase by soil depth. It means that migration of clay from upper to lower part of soil profiles happened in each land use. This was highly possible to happen, since the annual rainfall of the area was very high. High SOM content of the soil and rather fast soil permeability indicated high leaching (downward movement of water in soil profile) by carrying some clay particles and SOM as well.

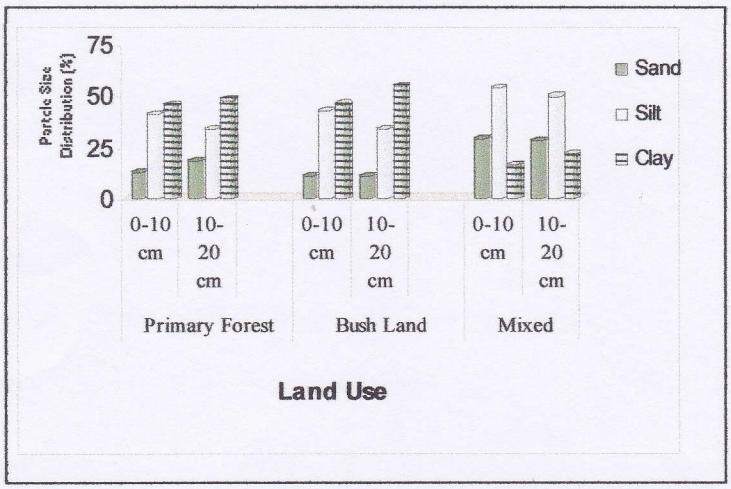

Fig.2. Particle size distribution of soils in Bukik Pinang-Pinang

2. Bulk Density and Total Pore

Soil bulk density and total pore as shown in Fig. 3 and 4 were not significantly different among the types of the land use. This was due to the texture and the OM content of the soil. Soil having fine texture will have low bulk density (BD) and high total pore, while coarse texture will be the vice versa. Then, soil with high SOM will have low BD and high total pore. Therefore, even though soil under mixed perennial trees had coarser texture, the values of the bulk density and the total pore were not significantly different from the other land use, because it had higher SOM content compared to primary forest and bush land.

Fine textured soil on the primary forest combined with much roots in soil profile had lower soil bulk density than bush land use. The difference could be due to the contribution of roots, which was higher density in soil under forest than that under bush land. Therefore, even though the class textured was the same, the bulk density was different.

At mixed perennial trees, on the other hand, the value of the BD was lower than those at other land use, even though it had coarser soil texture. Lower BD of the soil under mixed perennial trees was due to its high SOM content. Soil organic matter content can reduce soil mass per unit volume. Therefore, soil organic matter can modify textural characteristics of the soils. As reported by Yulnafatmawita et al (2009) that SOM content did not only decrease soil BD, increased total soil pores, but it also improved stability of aggregates. There was positive linear correlation between SOM content and soil aggregate stability (Yulnafatmawita, 2006). Stable soil aggregates is really important to create to avoid aggregate dispersion or degradation as soil is introduced to water.

The value of soil BD is negatively correlated to percentage of total soil pores. It can be compared between Figure 5 and Figure 6. Soil on the top 0-20 cm depth under mixed perennial trees showed the highest total soil pore. It happened since it had the lowest soil BD among the types of land use. High total soil pore combined with high SOM content indicated that the soil was loose enough for plant roots to grow and develop.

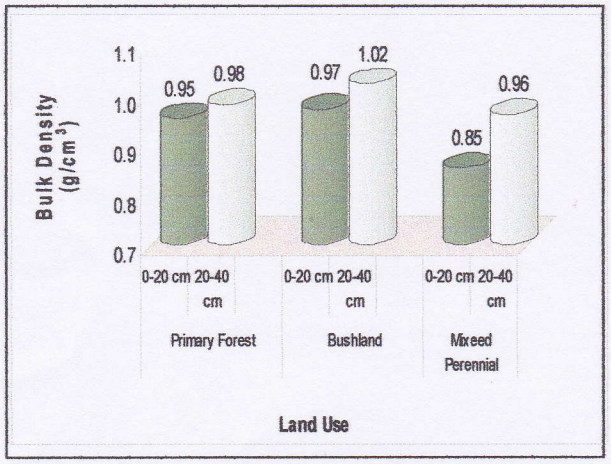

Fig. 3. Bulk density of soils in Bukik Pinang-Pinang

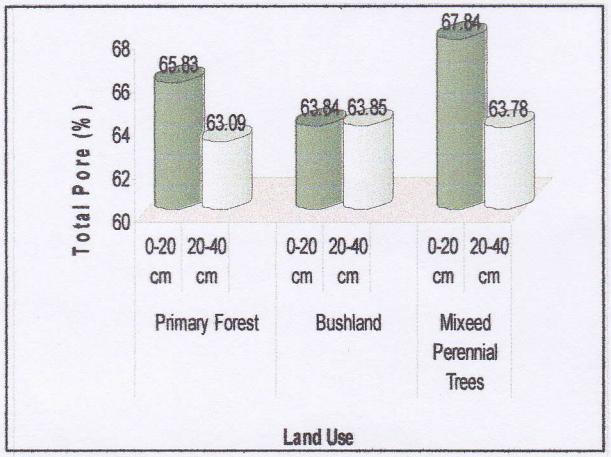

Fig. 4. Total pore of soils in Bukik Pinang-Pinang

3. Soil Permeability

The rate of water movement within soil profile ranged from rather fast to fast (Fig. 5). It was affected by soil texture, SOM, and biopores as well. Coarse textures will increase permeability rate of the soils due to their high macropores percentage. On the other hand, fine texture can have high permeability rate if the soil has high SOM content, or has biopores. Rate of permeability in soil under Bukik Pinang-Pinang were not significantly different. This was due to coarser texture under mixed perennial trees and high biopores under primary forest ecosystem. Therefore, bush land ecosystems had a bit lower permeability rate, due to fine texture and low biopores.

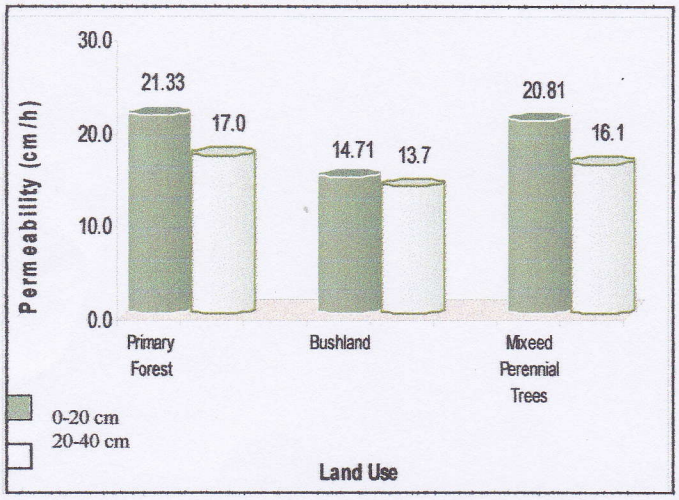

Fig. 5. Permeability of soils in Bukik Pinang-Pinang

Higher permeability rate of top soil than lower layer related to the difference of the particle size distribution and the SOM content of the soils between the depths. As top 20 cm soil in each land use had higher SOM and lower clay content, the permeability became higher than that at the 20-40 cm soil depth.

CONCLUSION

Based on data during field survey and laboratory analyses, it can be concluded (for the first set of data) that land use change from forest into mixed perennial trees (after >50 years without cultivation, but it was fully and permanently covered by under storey plants) and bush land (after approximately 20 years left and grown by plants without cultivation) tended to increase the SOM content from 0 to 40 cm depth. It could be inferred that, permanently grown trees with lower plants covering the surface of the soil is important to maintain SOM content of the cleared forest area. SOM content affected soil properties. Land use change in Bukik Pinang-Pinang did not significantly affect the soil physical properties (soil BD, soil porosity, and soil permeability). The difference of soil texture class among the land use was much attributed on the soil parent materials.

ACKNOWLEDGMENT

Author would like to thank DP2M Directorate General of Higher Education in Indonesia which gave financial support for this research, as well as my students, especially Dedy Hanafi, Suci Betrianingrum, Arief Fauzan Hakim, and Ricci Enrella who helped in field and laboratory work.

REFERENCES

Australian Greenhouse Office (AGO). (2002). National Greenhouse Gas Inventory 2000 with Methodology Supplements. Australian Greenhouse Office, Annual Report.

Irianto, G. 2004. Menyoal Alih Fungsi Lahan, Kekeringan, dan Ketahanan. Tabloid Sinar Tani.

Ogiono, K.,.Hotta, M., Tamin, R. dan Yoneda, T. 1984. Forest ecology of gunung Gadut Area. Sumatra Nature Study (Botany, Kyoto.

Rasyidin, A 1994. The method for measuring rates of weathering and rates of soil formation in watershed. *Dissertation. Tottory Univ. Japan, 110 p.*

Wakatsuki, T., Saidi, A. and Rasyidin, A. 1986. Soil in topsequence of the gunung Gadut tropical rainforest, West Sumatra. *South East Asian Studies 24(3):243-262*

Yulnafatmawita, So, H.B., Dalal, R.C. and Menzies, N.W. 2003a. CO_2 emission from different soil fraction following physical disruption: Implication for tillage practices. *Proceeding on the 16th Triennial Int'l Soil Tillage Res.Org.(ISTRO) Conference 13-18 July 2003, Brisbane Australia*

Yulnafatmawita. 2006. Hubungan antara status C-organik dan stabilitas aggregat tanah Ultisol Limau Manis Padang akibat perubahan penggunaan lahan. Proceeding Seminar Tahunan BKS 25-28 April 2006, Jambi

Yulnafatmawita, Luki, U., dan Yana, A. 2007. Kajian Sifat Fisika Tanah Beberapa Penggunaan Lahan di Bukit Gajabuih Kawasan Hutan Hujan Tropik Gunung Gadut Padang. *J. Solum Vol. IV No.2 Juli 2007: 8-19*

Yulnafatmawita, Asmar, dan Enrella,E. 2009. Pengukuran Infiltrasi Tanah Bukit Pinang-Pinang Kawasan Hutan Hujan Tropik Gunung Gadut Padang Di Laboratorium. *J. Solum Vol. VI No. 2 Juli 2009:78-86*