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Organic carbon sequestration under selected land use in Padang city, West Sumatra, Indonesia

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Abstract. Organic carbon is a potential element to build biomass as well as emitting CO_2 to the atmosphere and promotes global warming. This research was aimed to calculate the sequestered Carbon (C) within a 1-m soil depth under selected land use from 6 different sites in Padang city, Indonesia. Disturbed and undisturbed soil samples were taken from several horizons until 100 cm depth at each location. Soil parameters observed were organic carbon (OC), bulk density (BD), and soil texture. The result showed that soil OC content tended to decrease by the depth at all land use types, except under rice field in Kurao-Nanggalo which extremely increased at >65 cm soil depth with the highest carbon stock. The soil organic carbon sequestration from the highest to the lowest according to land use and the location is in the following order mix garden- Kayu Aro > mix garden- Aie Pacah > Rangeland- Parak Laweh >seasonal farming- Teluk Sirih > rice field- Kampuang Jua.

1. Introduction

Carbon (C) is considered to be one of the elements contained in the greenhouse gases (CO_2, CH_4, CFCs, HCFCs and HFCs). Therefore, an effort to sequester C becomes one among the answers for climate change control. As stated by Lal [1] that C-sequestration was the net rate of atmospheric CO_2 reduction by transferring into other long-lived global pools involving oceanic, pedologic, biotic, and geological strata. The C-sequestration is a method that might help to limit emissions and have potential to alleviate the risks of climate change [1,2].

A carbon sink is defined as storing CO_2 removed from the atmosphere or captured from emissions in other forms. Carbon is stored within terrestrial ecosystems for about 2110 Pg, almost three times the amount in the atmospheric CO_2, with 74% is stored by soils [1]. Soil organic carbon is estimated to be 684–724 Pg of C in the upper 30 cm, 1462–1548 Pg of C in the upper 100 cm soil profile [3].

The quantity of carbon sink in soil is determined by the types of land use and the management applied in each location. As found by Liu *et al.* [4] that the amount of biomass input into the soil was *strongly affected by land-use. Plants capture CO_2 from and release O_2 to the atmosphere during* photosynthesis process. Therefore, the more vegetation growing on a land more carbon is sequestered or removed from the atmosphere. Carbon stocks in soil decreased by 0.39 Mg/ha/y due to land conversion [5]. Moreno *et al* [6] found that the highest SOC stocks within a 4-m depth in tropical Colombia were found under primary forest (227.9 Mg ha^{-1}) > secondary forest (192.5 Mg ha^{-1}) > pasture (171.2 Mg ha^{-1}). Soil OC and easily decomposed OC in aggregates under grassland and forestland were higher than those under farmland.

Johnson *et al* [7] stated that agriculture can be a source of greenhouse gases and it can also be a sink for CO_2 through C sequestration into biomass products and soil organic matter (SOM). SOM can be found intra or inter soil aggregates protects from microbial attacks and known as physically protected OM. On the other hand, it is exposed and easily attacked by degrading microorganisms. Liu [4] found that soil OC and easily decomposed OC under farmland in the Loess Plateau of China concentrated in < 1 mm macro-aggregates, in others in > 1 mm. Soil OC and easily decomposed OC within aggregates in grassland and forestland were higher than in farmland.

Land use change is considered as the primary sector that contributes to greenhouse gas emissions. The CO_2-eq emissions increased about six times in 2005-2009 compared to that in 2000-2005 (681 006.94 tons of CO_2-eq per year) as agricultural land conversed to settlement for approximately 11.12% in Bogor, Indonesia from 2000-2009 [8]. Novara *et al.* [9] in Mediterranean areas found that land use conversion, vegetation type, and management practices, which control biogeochemical and physical soil properties, affected CO_2 emissions and SOC sequestration. Chen *et al* ([10] found that suburban and rural areas in Southern China had higher soil C content than that in an urban area.

The number of OC sequestered in soil is also affected by the soil properties, besides the types and density of plants. Yulnafatmawita [11] and Yulnafatmawita *et al* [12] found that types of soil texture affected SOM content. Clay content was found to be positive-linearly correlated with SOM content. The higher the clay particle percentage in a soil the more the SOM content. It was found that there was 18.8 g SOM/kg soil having 82% clay [13] and 12.3 g SOM/kg soil having 67% clay [12] on the surface of 20 cm soil depth in Ultisols Limau Manis Padang.

Furthermore, the amount of SOM is also determined by the management applied to the land. Cultivated soil used to contain 50-75% of the original SOC pool [1]. Under clay textured soil being intensively cultivated, for example, the percentage of SOM could be lower than that under the loamy textured soil in a forest. A forest with plenty of woods is potential to catch carbon (in form of CO_2) from the atmosphere, as well as at land which is never cultivated accumulates carbon (in form of SOM) in the soil.

Land use in a city is dominated by building either for private or public facilities. In Padang City, a capital of West Sumatra Province, some land has been uncovering, especially the area close to the coastline, and some is still being covered by primary forest (±51%) based on statistical data [14]. The rest was for agriculture (rice field, mix garden, bush, seasonal farming), rangeland, animal husbandry and fishery, then for housing and other buildings, infrastructure, and other facilities. How much carbon was sequestered in different types of land use in an urban area under wet tropical climate is interesting to study. This research was aimed to identify the carbon sequestration under different types of land use in Padang city, Indonesia.

2. Material and methods

2.1. Research site

Our study was focused in Padang, a mid-sized city in Indonesia, covering an area approximately 694.96 km^2, having population 902,413 with the density was 1,299 people/km^2 [14]. It is located on the West Coast of Sumatra, Indonesia (0°44′-1°08′ S, 100°05′-100°34′E) (Fig. 1) with the altitude 0-1853 m *asl*. The region has a wet-humid tropical climate, receiving 3,552 mm of precipitation in 2016 and average annual daily minimum and maximum temperatures of 26.10°C and 31.30 °C, as well as 73% and 95% relative humidity, respectively. The climate of the city belongs to wet tropics, classified as *Af* (very wet) class according to Smith and Ferguson [15].