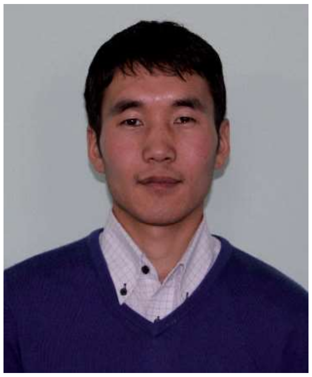
SOIL ORGANIC CARBON CHANGES OF URBAN AND SUBURBAN AREAS IN STEPPE AND DRY STEPPE ZONES IN MONGOLIA



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Abstract: The urban population and urbanized land in Mongolia have same increased last 80 years. Urban developments have grown at unpresented rates with unknown consequences for ecosystem functions. In Mongolia, the effect of urbanization on the stock of soil organic carbon never been studied before. In this study we compared the soil organic carbon (SOC) pools in several land use types with native soil. We collected from urban and non-impacted (near the soum) places (several middle scale city-Aimag, soum) in steppe and dry steppe eastern Mongolia. Which include 3 aimag center and 4 soum center. The result showed significant difference in the sampling and land use types. Especially, Urban soils had lower Soil organic content than Native soil and conversely SIC content higher. SOC stocks decreased due to land use. In Choibalsan city's average SOC stock had altered -56% at top 30 cm layers, Chinggis khaan city's SOC stocks decreased -42%, Baruun urt city's SOC stocks decreased -17%. SOC stocks changing rate between 3.85%-75.15% and relatively high. The mean SOC stock changes of Urban soil in eastern Mongolia is higher than central Mongolia (Native-pasture).

Keywords: Soil organic carbon, in organic carbon, urban soil, land use, changes.

Introduction

Urban areas cover less than 1% of the earth's surface, more than 50% of world's population lives in cities and town (Schneider, 2010). Urban growth is understood as the expansion of built-up areas that implies changes in Land Use/Land Cover (LULC). The recently projection by the United nations press revealed more people live in in rural areas, with 55 % of the world's population residing in urban areas in 2018. In 1950, 30 % of the world's population was urban, and by 2050, 68 % of the world's population is projected to be urban (United nation, 2018). Each year, global coverage of urban land has reached approximately 0.63% in 2010 (Liu, 2018) but population number will be increase faster (Angel et al., 2011). The impact of urban area increases on the global environment more direct effect in the future (Grimm et al.,2008).

Soil carbon stock, including that Soil organic carbon and Soil inorganic carbon is largest carbon in the terrestrial ecosystem. Soil organic carbon is that very sensitive for any land use and activity. But, Effect of urbanization on soil remain poorly characterized (Lehman & Stahr., 2008) compared with native soils in the World, especially in Mongolia. Some Russian scientist observed Urban soils are generally higher pH values, coarser texture, and higher Bulk density; mineral composition totally disturbed and changed, and they are enriched in carbonate and iron oxides (Gerasimova, 2003).

In this study, we report SOC stocks for the urban sites in the Eastern Mongolia which 4 provinces and 4 soums. The objective of this study were quantity of SOC stock in different land use types (Street-unpaved road, ger dis-

-trict, black market-supermarket, building areas) and estimate to the changes of SOC concentrations (in depth 30 cm) compared with same soil classification types.

Materials and Methods

Study area and sampling

The study was conducted in the south and eastern Mongolia, Especially in Dornod, Sukhbaatar, Khentii and Dundgobi provinces (45°40´-48°04´N, 106°50´-114°27´) (Figure 1). Including several soums (1-Gurvansaikha, 2-Bayanjargalan, 3-Baruunurt, 4-Dashbalbar, 5-Choibalsan, 6-Khulunbuir, 7-Chinggis khaan) in the above mentioned provinces. We used a Manual soil sampling methods (used for spoon) from 25 sampling sites. Soil samples were collected from 5x5 m plots of different land uses were randomly designed in each plots. The top 30 cm surface of the two replicated in each plots. Soil organic carbon in the top 30 cm of the mineral soil according to IPCC recommendations which state that it is good practice to measure soil carbon to a depth of at least 30cm (Penman et al., 2003).

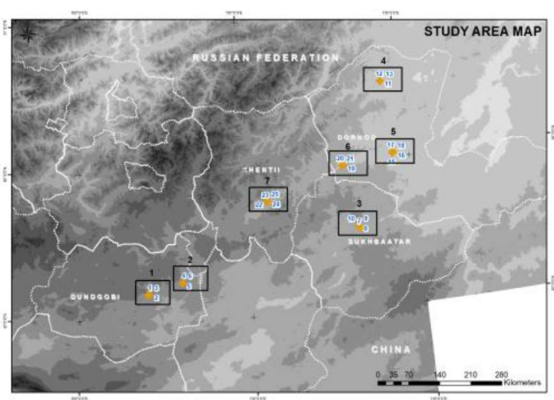

Figure 1. Soil sampling area

All study sites divided into several groups based on land use types.

Laboratory analysis

Soil samples were air dried and sieved to analyze the chemical properties (<2 mm for analysis). Using Thermal pH meter, Soil pH was determined in distilled water at soil-to-solution ratio. The SOC was analyzed using potassium dichromatic oxidation method (Tyurin method) and Soil Inorganic Carbon (Calcium carbonate) analyses using volumetric analyses. Texture was determined using the percentage of sand, silt and clay as determined by the hydrometer method. Also, Soil bulk density was determined using for the Gravimetric method.

For all data, the density of carbon (Batjes, 1996) in a unit area (1 m^2) was calculated as follows:

$$T_d = \sum_{i=1}^{k} pi\ Pi\ Di\ (1 - Si)$$

where T_d is the total amount of organic carbon over depth, d, (in Kg m^{-2}), i is the bulk density of layer i (Mg m^{-3}), P_i is the proportion of organic carbon in layer i (g C Kg^{-1}), D_i is the thickness of this layer (m), and S_i is the volume of the fraction of fragments >2 mm.

Results

Soil organic carbon concentration

Highest soil organic carbon concentration was located in the non-eroded soils close to the town compared with urban soils in eastern Mongolia (Figure 3). Also, the content and stocks of non-eroded (native soil) soils higher than urban soil carbon. Several studies assumed that urban soil organic carbon higher than native soil organic carbon (Brown, 2012; Luo,2014). I this study shows that contrast result with previous study. It's directly depend on soil reclamation and gardening in soil after civilization time.

Soil bulk density

For road and building construction, heavy machinery used, which destroys soil aggregates, compacts the package of particles, decrease porosity (Jo, 1995). Due to human activity soil bulk density clearly higher than non-impacted soils. The average density was significantly higher in urban soils 1.668 gm/cm^3. Whereas it is equal on average to 1.432 gm/cm^3 in non-impacted soil (Table 1). Urban soil restores its structure with time and it approaches the native value.

Soil properties

Large variations were observed within urban land, natural, and throughout the study area as a whole for SOC, SIC, Gravel content, and Bulk density (Table 1). The coefficient of variations (CV) of soil properties ranged from 6% for urban soil pH to 304% for urban soil salinity. In contrast, Natural soil properties had relatively low CV compared with Urban soils.

The comparison of soil properties between urban and natural soils revealed significant differences, except for SOC.

A simple subdivision of urban soils by the evolution stages was suggested in USA (Park et al., 2010). This classification distinguishes two soil groups depending on the urban development stages, for instance first step under construction activity when soil degraded and after construction activity soil condition will recover.

Effect of the land use

There were statistically significant differences in soil organic carbon stock among urban and non-eroded soils (Figure 2, 3). For all urban sites (excluding Gurvansaikhan soum) had lowest SOC stock, while non eroded soils had highest. SOC stocks decreased due to land use for last several decades. In Choibalsan city's average SOC stock had altered -56% at top 30 cm layers, Chinggis khaan city's SOC stocks decreased -42%, Baruun urt city's SOC stocks decreased -17%.

In Dornod provinces soum's SOC stock decreasing level higher than aimag center. For instance, Dashbalbar and Hulunbuir soums SOC stock decreased -64-70%.

In contrast, Gurvan saikhan soum center's SOC stock had increased 5.6% (Figure 3f). It's due to infrastructure activity and gardening. Soum governors pay attention to constructing new paved road and making shelter, reforestation. Unpaved road and bare ground one of the high risk surface for Soil organic carbon by any activity.

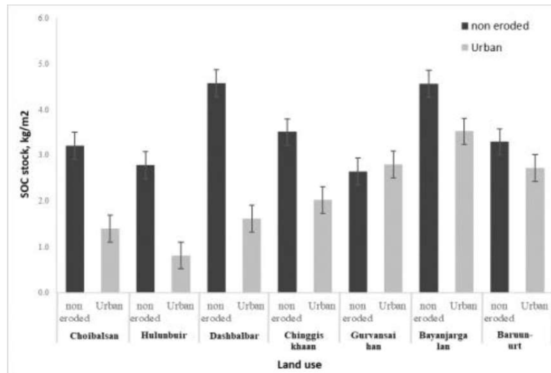

Figure 2. Mean Soil organic carbon Stocks (0-30 cm) of main land use types in study.

In the arid zone, where watering of urban soils improves the greenery state as compared to the poor native vegetation. American scientist observed at first stage of Urban development, SOC of arable land soils as compared with native soils in the temperate climate and at the second stage SOC stock rises upon urbanization in all soils (Pickett et al., 2001).

Comparing province center and soum center sites of same land use type, soum center's ger district areas had significantly lower SOC stocks than the same types located in aimag center areas (Figure 3-abc). Aimag center infrastructure well developed compared with small soum centers in Dornod province.

Soil organic carbon changes of Urban soils

In Mongolia, Previous studies assumed that Dark Kastanozem soils Soil organic matter content decreased for 10% during last three decades in central Mongolia (Batkhishig, 2017).

More recent studies concluded that Dark Kastanozem soil soils SOC stock

Table 1. Descriptive statistics of soil properties sampled from urban and native soils in study area

.	Urban land use				Native soil			
	Mean	Min	Max	CV	Mean	Min	Max	CV
Density	1.7	1.4	1.9	8.4	1.4	1.2	1.7	37
pH	7.9	7.2	9.3	5.7	7.3	6.4	7.7	35
SOC	0.6	0.2	1.7	67	1.1	0.6	1.5	47
SOC stock	2.0	0.4	5.0	62	3.5	2.6	4.6	22
CaCO	1.3	0.0	7.6	162	0.0	0.0	0.0	0
Stone	31	5.1	57	48	20	0.1	35	70
Salinity	1.6	0.0	21	304	0.1	0.1	0.2	41

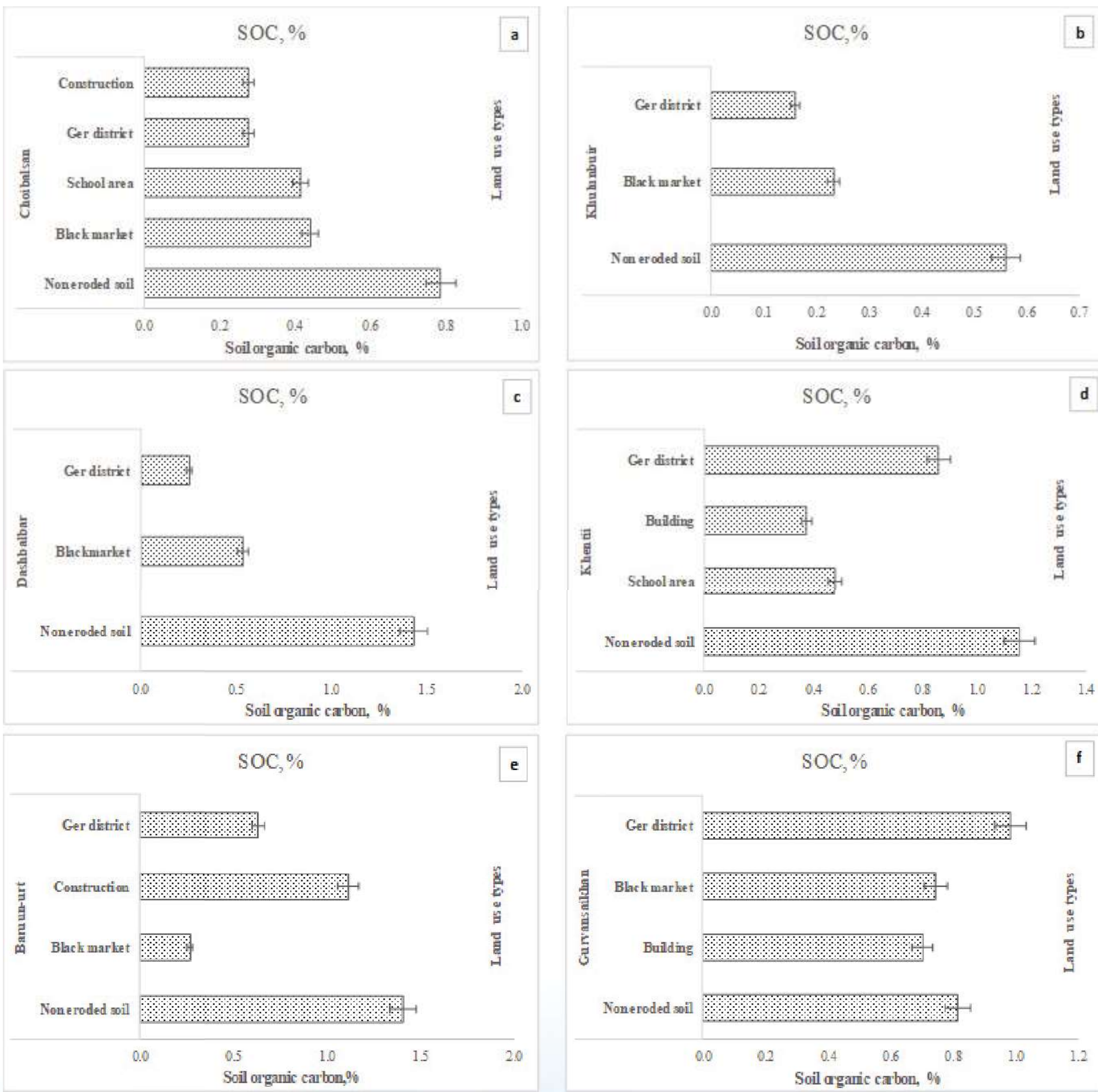

Figure 3. Mean Soil organic carbon Stocks (0-30 cm) of each land use types in Eastern Mongolia.

decreased 16.5% (14.5 t/he) in central Mongolia (Batkhishig & Ganzorig, 2018). One of the main impact is overgrazing and wrong pasture management.

The result of our study showed that SOC stock changes different in the land use types and more important things is SOC stock hugely altered from the Urban soils. A greater than tenfold difference in SOC stock observed in Black market (supermarket), Ger district zones in Dashbalbar (changes rate-75.1%), Hulunbuir (changes rate-70.4%, Dornod) and Baruun-Urt (changes rate-73.6%, Suhbaatar). SOC stocks changing rate between 3.85%-75.15%. The mean SOC stock changes of Urban soil in eastern Mongolia is higher than central Mongolia (Native-pasture).

One the other hand, Native soils SOC stocks changes not muoch higher than impacted Urban soil. Kastanozem soils SOC stock 27.8-45.7 t/he and Light Kastanozem soils SOC stock 26.5-45.6 t/he in study area (Table 2).

Urban soils SOC stock 8.2-36.3 t/he. Lowest soil carbon stock observed in Hulunbuir soum, especially in Ger district land use area and highest carbon stock in Bayanjargalan soum.

Table 2. SOC stocks rate and changes in Eastern Mongolia.

Province, soum	Native	Urban		SOC stock changes, %
	SOC stock, t-C/ha			
Dornod, Choibalsan	32.3	14.2	School	-56.0
		17.9	Black market	-44.5
		13.2	Ger district	-59.1
		10.6	Construction	-67.1
Dornod, Khulunbuir	27.8	9.9	Black market	-64.3
		8.2	Ger district	-70.5
Dornod, Dashbalbar	45.7	11.4	Ger district	-75.1
		16.1	Black market	-64.6
Khentii, Chinggis	35.1	12.6	School	-64.0
		10.2	Building	-71.0
		30.1	Ger district	-14.1
Dundgobi, Gurvansaikhan	26.5	20.0	Building	-24.3
		25.5	Black market	-3.8
		30.3	Ger district	14.3
Dundgobi, Bayanjargalan	45.6	36.3	Ger district	-20.3
		34.2	Black market	-24.8
Suhbaatar, Baruun-urt	32.9	8.7	Black market	-73.6
		31.1	Building	-5.46
		28.4	Ger district	-13.7

Our study revealed that Mongolian medium and small sized town soil's not sequestering carbon, conversely altering huge amount of organic carbon. In developed countries urban soils contain higher SOC stock than native soils, it is direct effect for the park, gardening and infrastructure in the urban. Our result requires to be emphasized that developing urbanization and rising expenses for greenery in cities, towns contribute to the growth of the soil carbon pool.

Conclusion

The study of urban soils becomes acute due to growing urbanization in Mongolia, as compared to the background, ecological situation is radically different in a city. The comparison of soil carbon storage in the different land use of urban areas with that of non-impacted areas reveals a certain decrease in carbon storage. This study reveals that the topsoil carbon stocks in the eastern Mongolian cities have a high spatial variability, and that SOC have a low range compared with native soils.

The significant differences in soil organic carbon stocks among different land use types indicate the decisive role of the human effect on the nature of urban soils.

Acknowledgments

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