

# Estimation of soil organic carbon stocks: A case study of forest soils in the green zone of Bogd Khan mountain

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## CITATION

Lkhamsuren Byambajav, Amarsanaa Sainchuluu, Khishigsaikhan Adiyabazar. Estimation of soil organic carbon stocks: A case study of forest soils in the green zone of Bogd Khan mountain. International Journal of Social Science and Humanities Research-MIYR 2025, 5(3), 19-30.  
<https://doi.org/10.53468/ijsshr-miyr.v5i3.6>

## ARTICLE INFO

Received: 29 June 2025

Revised: 01 July 2025

Accepted: 18 September 2025

Available online: 30 September 2025

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**Abstract**— This study examined soils in the 25 -hectare forest area of the green belt in the Ar and Uvur Zaisan valleys of Bogd Khan Mountain. Soil profiles were sampled, morphological descriptions were conducted, and agrochemical properties were determined, including the content and stocks of soil organic carbon (SOC). The forest soils of the study area are classified as mountain mollic umbrisols. In urban green spaces, intensive human activities— such as high population density, increased vehicular and machinery traffic, and inappropriate land use planning—have led to soil and surface layer degradation, compaction, and erosion, as well as a reduction in plant species diversity, resulting in accelerated land degradation. Therefore, we urgently require effective measures to protect the green belt forests and implement optimal land-use management. The aim of this study was to determine SOC content and stocks in the green belt forests of Bogd Khan Mountain, specifically in the Ar and Uvur Zaisan valleys of Ulaanbaatar. To achieve this, we assessed soil fertility indicators and estimated SOC stocks within the study plots. Results from the Uvur Zaisan valley showed that soils in the 0–30 cm layer were moderately acidic (pH 5.20–5.80), with humus content of 8.1–14.1%, SOC of 4.7–8.2%, cation exchange capacity of 10.50–70.00 mg, phosphorus content of 0.77–1.49 mg, and potassium content of 32.00–60.00 mg. In comparison, soils from the Ar Zaisan valley were slightly acidic (pH 6.08–6.70), with humus content of 7.0–12.5%, SOC of 4.0–7.2%, cation exchange capacity of 11.0–60.7 mg, phosphorus content of 0.77–1.00 mg, and potassium content of 37.50–81.00 mg. SOC stock assessments revealed 148.67 t ha<sup>-1</sup> in the 0–30 cm soil layer of Uvur Zaisan forests and 137.29 t ha<sup>-1</sup> in Ar Zaisan forests.

**Keywords**— Forest soil, Soil organic carbon (SOC), Soil organic carbon stock (SOC stock), Soil degradation, Green belt, Bogd Khan Mountain

## 1. INTRODUCTION

The soil cover is not only the fundamental basis of a given region's ecosystem but also one of the key factors influencing human settlement and economic development. Soil plays diverse and critical roles in ecosystems and is considered an essential natural resource. It is also a major reservoir of organic carbon on Earth, thus having a significant influence on climate regulation and land cover change [1]. The soil organic carbon (SOC) reservoir is roughly double the size of that contained in terrestrial vegetation and nearly three times greater than that in the atmosphere [2]. Consequently, even minor alterations in soil organic carbon can significantly impact the global carbon cycle and climate change [3].

Soil organic carbon stocks play an important role in global climate processes, including carbon sequestration and emissions. To accurately assess terrestrial carbon

dynamics and estimate carbon reserves, it is essential to precisely measure SOC content along with other influencing factors [4]. The size and dynamics of the soil organic carbon (SOC) pool play a crucial role in assessing and predicting global climate change. Accurate estimation of SOC stocks is essential for elucidating the interactions between atmospheric and terrestrial carbon [5].

Mongolia's soils account for approximately 0.94% of the global soil organic carbon (SOC) stock. This places the country 14th worldwide in terms of total SOC reserves [6]. The estimated total SOC stock in Mongolia's topsoil (0–30 cm) is 6,553.1 megatons (Mt). The 0–30 cm surface layer typically contains 43.0 tons of organic carbon per acre. Mongolia's total soil organic carbon resource for the 0–100 cm depth range is 9,937.3 Mt, averaging 65.2 tons of organic carbon per hectare.

Urban centers, especially Ulaanbaatar, the capital of Mongolia, face significant environmental challenges such as inadequate air quality, soil contamination, erosion, land degradation, traffic congestion, insufficient green spaces, and scarcity of land and water resources. Carbon dioxide (CO<sub>2</sub>) is the most common air pollutant, with green plants being the sole organisms capable of decreasing its concentration in the atmosphere [8]. Urban green infrastructure has several ecological benefits. Vegetation absorbs pollutants from industrial emissions, power plants, and cars; lowers noise pollution by 8–10 dB; filters airborne particulates; and contributes to air purification. A hectare of trees and bushes may cleanse as much as 18 million cubic meters of air, absorbing 30–35% of air contaminants. Broadleaf trees can reduce noise by 26%, trap 21–76% of dust particles, and lower extreme temperatures by 2–3°C. Bright-colored plants enhance soil water retention (up to 75%), increase air humidity by 4–7%, and stabilize air temperature by reducing solar radiation 10–15 times [9].

Furthermore, while an adult breathes approximately 9.5 tons of air per year, a group of seven trees with an average height of 12 meters can produce that much oxygen annually. In addition, 0.4 hectares of trees and shrubs can absorb 2.6 tons of CO<sub>2</sub> per year, equivalent to the carbon emissions produced by a car traveling 14,000 kilometers [10]. Soil is the unconsolidated upper layer of the Earth's crust, formed through the interaction of natural geosystem processes and the weathering of parent rock material [11]. Its formation is governed by five primary factors: climate, vegetation, parent material, topography, and time. In addition, human activities increasingly influence and alter soil properties over time [12].

Soil organic matter consists of plant and animal residues at various stages of decomposition, together with organic compounds that have been transformed and re-synthesized by soil microorganisms [13]. Organic matter is the most important sign of soil fertility because it changes the soil's biological, chemical, and physical properties [14]. Soils with a lot of organic matter have a lot of important nutrients like carbon, nitrogen, and phosphorus. They also have a good aggregate structure that makes it easier for air and water to move through them, which makes them great for plant growth [15].

Approximately 58% of soil organic matter, or humus, is composed of organic carbon. It consists of residues of plants, animals, and microorganisms derived from decomposition, as well as a wide range of organic compounds associated with soil minerals, which can be preserved in soils for thousands of years [16, 17]. Soils around the world have more organic carbon than the atmosphere and land plants put together [18]. According to estimates, soils around the world hold about 1,500 petagrams (10<sup>15</sup> g) of organic carbon [19].

SOC stocks and their stability are greatly affected by a number of natural and human-made factors, such as climate conditions, changes in land use, overgrazing, and bad farming practices [20]. Studies on how to measure soil organic matter show that soil that has been sieved through a 2 mm mesh has, on average, 12.8% more organic matter than soil that has been sieved through a 1 mm mesh [21]. Researchers have also looked into how fire affects SOC. When soils were burned, the amount of organic carbon in the top 0–4 cm layer dropped by 25%, and the SOC stock dropped by 19% [22]. A study of the steppe soils in central Mongolia over a long period of time found that the organic matter content in the 0–30 cm depth dropped by an average of 30.9% after 90 years. SOC stocks fell by 16.5% during the same time period, which is about 14.5 t/ha in the top 30 cm of soil [24]. In the steppe region of Tuvshruulekh soum, Arkhangai province, a study found that the average soil organic carbon (SOC) stock at the Ulziit Valley site was 60.8 t/ha at a depth of 0–30 cm.

The SOC stock averaged 53.3 t/ha on the north-facing mountain slope, where dark brown and stony dark brown soils are common. The south-facing slope, on the other hand, had a lot less SOC stock, with an average of 38.8 t/ha ( $P < 0.05$ ). The soils there are shallow stony dark brown, gravelly dark brown, dark brown, and gravelly brown. The soils on the north facing slope were generally thicker and had less coarse material than the soils on the south-facing slope. The valley floor had the most SOC, with an average of 115 t/ha in the top 30 cm and 315 t/ha at a depth of 1 m [25].

In Mongolia's high mountain and alpine areas, SOC stocks depend on the type of soil. For example, mountain peat soils had an average SOC stock of 191.1 t/ha, which is the same as 329.4 t/ha of soil organic matter. Mountain dark soils had 124.8 t/ha of SOC (215.1 t/ha of organic matter), and coarse humic soils had 90.3 t/ha of SOC (155.6 t/ha of organic matter) on average [26]. In croplands that had been farmed for 50 years, the amount of humus in brown soils went down by 1.82%, and the amount of SOC went down by 1.06% compared to nearby virgin soils with similar properties [27]. Based on 419 soil samples from 83 profiles in the central and eastern steppe regions of Mongolia, a full study found that the average SOC stock in dark brown steppe soils was 50.0 t/ha at a depth of 0–30 cm, 77.5 t/ha at a depth of 0–60 cm, and 97.8 t/ha at a depth of 0–100 cm [28].

Mining has caused a lot of SOC loss in Mongolia because it has damaged the soil. Recent reports say that mining has disturbed about 57,643.2 hectares of land. This disturbance has caused the loss of 3,134,939.1 tonnes of SOC from the 0–30 cm soil layer and 4,952,477.8 tonnes from the 0–100 cm depth [29]. In the winter, we took soil and fine root samples from Scots pine (*Pinus sylvestris*) and Siberian pine (*Pinus sibirica*) in the forested area of Nukhtiin Am, Bogd Khan Mountain. Researchers collected fine roots of Scots pine (*Pinus sylvestris*) and Siberian pine (*Pinus sibirica*), along with soil samples, from the Nukhtiin Valley of Bogd Khan Mountain. The ectomycorrhizal community was identified during the winter season, and the potential activities of enzymes involved in soil organic matter decomposition were analyzed. In addition, total soil nitrogen, pH, soil moisture, dissolved organic nitrogen, dissolved inorganic nitrogen, and dissolved organic carbon were determined [30]. At a depth of 0–30 cm, brown soils in the dry steppe zone had an average SOC stock of 35.6 t/ha. At a depth of 0–60 cm, it was 57.1 t/ha, and at a depth of 0–100 cm, it was 68.7 t/ha. For light brown soils, the SOC stocks at the same depths were 19.6, 28.8, and 33.8 t/ha, respectively [31].

The content of coarse fragments in the soil was calculated using both mass-based and volume-based methods to assess soil organic carbon (SOC) stocks. The results indicated that the mean SOC stock at 0–20 cm depth was 55 Mg ha<sup>-1</sup> when coarse fragments were not considered (M1), 42 Mg ha<sup>-1</sup> when coarse fragments were accounted for by mass (M2), and 50 Mg ha<sup>-1</sup> when accounted for by volume (M3). [32]. According to studies on SOC stocks of desert brown and light brown soils in the Gobi, saline soils contained 54 t ha<sup>-1</sup> of SOC within the 0–100 cm layer. For other soils, SOC stocks within 0–100 cm were 27.6 t ha<sup>-1</sup> in brown soils, 17.5 t ha<sup>-1</sup> in light brown soils, and 38.6 t ha<sup>-1</sup> in Gobi red soils. The vertical distribution of SOC in Gobi soils indicated that 60–72% of the total SOC stock was concentrated in the upper 0–60 cm, with up to 90% of the stock stored in the 5–30 cm layer [33], [34].

Other studies conducted in areas near our research site reported agrochemical properties of soils in the Khandgait and Jigjid valleys, including humus content, pH, EC, available P and K, and mechanical composition. In particular, in plots with 3.6% humus content, the flowering rate of trees reached about 70%, whereas in plots with around 1.5% humus content, the flowering rate dropped below 40% [35]. Furthermore, in the mountainous slope areas around Ar Zaisan in Bogd Khan Mountain, the loss of soil humus stocks (t ha<sup>-1</sup>) was quantified, and an ecological–economic assessment was carried out [36].

## **2. RESEARCH MATERIALS AND METHODS**

### **2.1 Study Area**

The study was conducted within a total area of 35 hectares located in the green zone and limited use green infrastructure of Bogd Khan Mountain, specifically within the territories of the 14th and 22nd khorroos of Khan-Uul

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District, Ulaanbaatar City. The selected sites include the northern (Ar Zaisan) and southern (Uvur Zaisan) slopes of Bogd Khan Mountain (Figure 1).

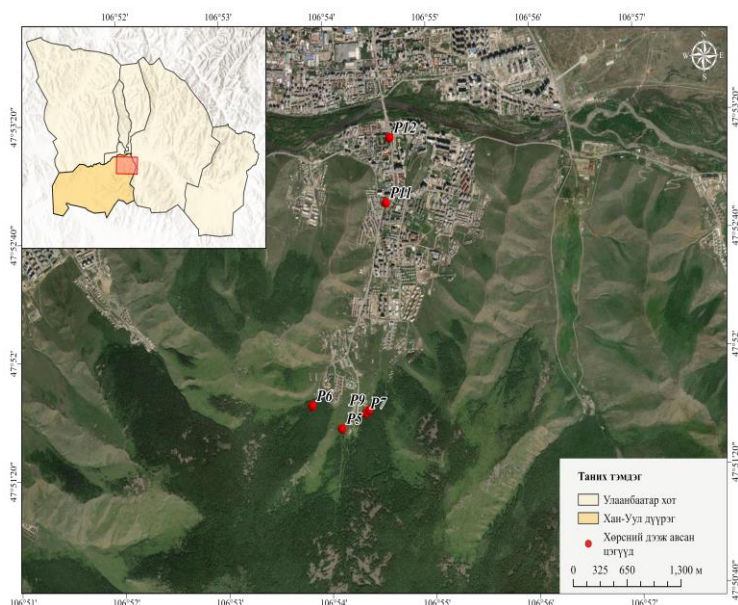


Fig 1. Green belt forest area, sampling points

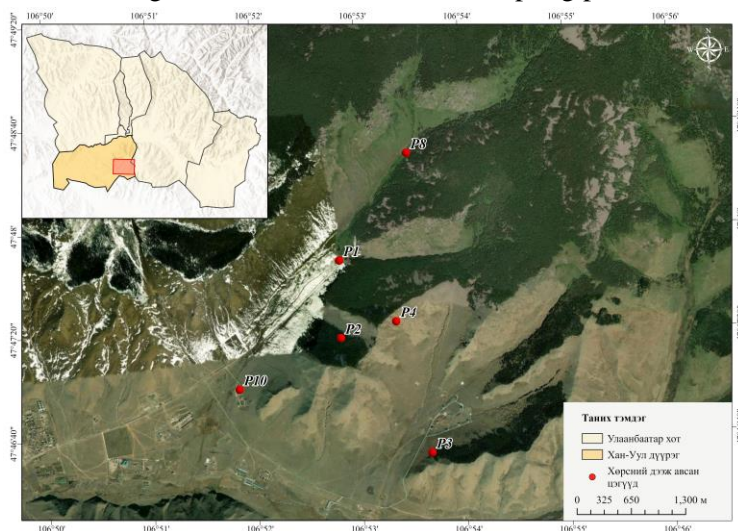


Fig 2. Green belt area, sampling points

The study area comprises two versions: A, a 25-hectare forest in the green zone, and B, a 10-hectare green space (Table 1).

Table 1. Agrochemical properties of forest soils in the green zone

| Types of study area           | Number of sampling plots | n | Sampling depth (cm) | Total number of samples | Duration      |
|-------------------------------|--------------------------|---|---------------------|-------------------------|---------------|
| A - Forest area in green zone | 9                        | 4 | 0-5                 | 36                      | May-September |
|                               |                          |   | 5-10                |                         |               |
|                               |                          |   | 10-20               |                         |               |
|                               |                          |   | 20-30               |                         |               |
| B - Green space area          | 3                        | 4 | 0-5                 | 12                      | May-September |
|                               |                          |   | 5-10                |                         |               |
|                               |                          |   | 10-20               |                         |               |
|                               |                          |   | 20-30               |                         |               |
| <b>Total</b>                  |                          |   |                     | 48                      |               |

We cut soil profiles and made morphological descriptions to find out the morphological properties of the soil. N. I. Savinov used the dry method to measure the size of soil aggregates. We looked at the chemical properties of the soil in the following ways: we monitored the soil's reaction using a potentiometer; we used the Tjurin bichromate oxidation method to find out how much humus and organic carbon were in the soil; and we used the Machigin method to find out how much accessible phosphorus and exchangeable potassium were in the soil. We looked at the soil's physical attributes by measuring its mechanical composition with the Kachinskiy method, its bulk density using a cylinder and the gravimetric method, and its stone content with the mass method. We used the following formula to calculate how much organic carbon was in the forest soils in the green zone.

$$SOCstock = \sum_{i=1}^k Ri * Pi * Di (1 - Si)$$

SOCstock – Soil Organic Carbon stock (Kg m<sup>-2</sup>)

Ri – Bulk density (Mg m<sup>-3</sup>)

Pi – Soil organic carbon content (g C Kg<sup>-1</sup>)

Di – Thickness of the soil layer (m)

Si – Volume percentage of stones larger than 2 mm (%)

We used standard deviation, arithmetic mean, and correlation to analyze soil agrochemical properties.

### 3. RESULT

The forest soils in the study area's green zone are categorized as dark mountain forest soils.

Table 2. Agrochemical properties of forest soils in the green zone

| Depth of Sample (cm)      | pH        | Humus, %   | SOC, %    | Exchangeable Bases, meq/100g |            | Nutrient Elements, mg/100g    |                  |
|---------------------------|-----------|------------|-----------|------------------------------|------------|-------------------------------|------------------|
|                           |           |            |           | Ca                           | Mg         | P <sub>2</sub> O <sub>5</sub> | K <sub>2</sub> O |
| <i>Uvur Zaisan Valley</i> |           |            |           |                              |            |                               |                  |
| 0-5                       | 5.80±0.53 | 14.14±1.07 | 8.20±0.62 | 70.00±10.00                  | 27.00±0.01 | 1.49±0.57                     | 60.00±12.00      |
| 5-10                      | 5.25±0.09 | 10.94±1.04 | 6.62±0.61 | 56.00±6.00                   | 24.50±4.50 | 0.81±0.16                     | 32.00±8.00       |
| 10-20                     | 5.20±0.02 | 10.30±2.51 | 5.98±1.46 | 36.00±4.00                   | 10.50±3.50 | 0.77±0.01                     | 37.00±1.00       |
| 20-30                     | 5.26±0.09 | 8.19±2.26  | 4.75±1.31 | 37.50±7.50                   | 13.50±0.50 | 0.85±0.12                     | 37.00±1.00       |
| <i>Uvur Zaisan valley</i> |           |            |           |                              |            |                               |                  |
| 0-5                       | 6.08±0.09 | 12.57±4.89 | 7.29±0.95 | 60.75±14.50                  | 24.25±6.72 | 1.00±0.43                     | 81.00±32.39      |
| 5-10                      | 6.28±0.25 | 11.43±0.64 | 6.35±0.37 | 52.75±8.58                   | 17.50±6.18 | 0.95±0.23                     | 66.00±8.60       |
| 10-20                     | 6.47±0.24 | 9.81±2.79  | 5.69±1.62 | 46.5±12.34                   | 14.25±5.54 | 0.77±0.31                     | 46.50±4.56       |
| 20-30                     | 6.70±0.18 | 7.02±2.27  | 4.07±1.32 | 33.25±4.82                   | 11.00±2.55 | 0.87±0.04                     | 37.50±0.87       |

The results indicate that soils in the Uvurkhangai Zaisan Valley are relatively acidic (pH 5.2–5.8), whereas soils in the Ar Zaisan Valley are slightly acidic (pH 6.1–6.7). Humus content in the 0–5 cm layer was high (14.14% and 12.57%), and SOC reached 8.20% and 7.29%, respectively. In contrast, at 20–30 cm depth, humus content decreased to 7–8%

and SOC to 4–5%, indicating that organic matter accumulation is mainly concentrated in the upper soil layers. Calcium and magnesium concentrations also declined with soil depth in both valleys, with maximum values observed in the 0–5 cm layer (Ca = 70 mg-eq/100 g, Mg = 27 mg-eq/100 g). Regarding nutrient elements (P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O), P<sub>2</sub>O<sub>5</sub> content was highest in the Uvurkhangai Zaisan soils (1.49 mg/100 g), whereas K<sub>2</sub>O reached 81 mg/100 g in the Ar Zaisan soils, reflecting notable differences between the two sites. However, in both valleys, phosphorus and potassium concentrations decreased in the lower soil layers. These results suggest that land use characteristics and ecosystem conditions at the study sites directly influence soil organic carbon (SOC) stocks.

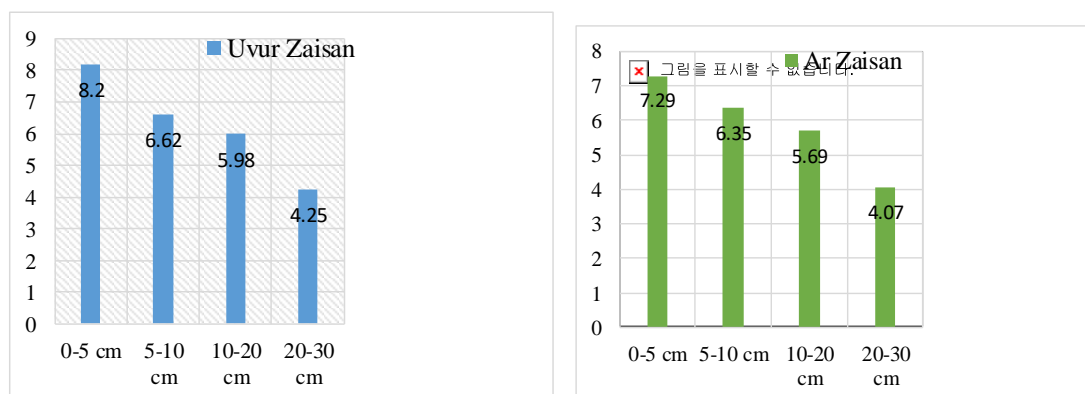


Fig 3 and 4. Soil Organic Carbon (SOC) Content (%) in Forest Soils of the Green Zone

According to the above graphs, soil organic carbon (SOC) content in Uvur Zaisan Valley was 8.2% at 0–5 cm, 6.6% at 5–10 cm, 5.9% at 10–20 cm, and 4.75% at 20–30 cm depth. In Ar Zaisan Valley, SOC levels were 7.2%, 6.3%, 5.6%, and 4.0% at the corresponding depths. Soil gravel content was determined using the mass method. Statistical analyses included calculation of the maximum (Max), minimum (Min), mean, standard deviation (SD), standard error (SE), and coefficient of variation (CV).

Table 3. Gravel Content in Soil

| Research scenario                  | max  | min | mean | SD   | CV   | SE   |
|------------------------------------|------|-----|------|------|------|------|
| Uvur Zaisan Green Zone Forest Soil | 6.15 | 0   | 2.02 | 2.4  | 1.19 | 0.73 |
| Ar Zaisan Green Zone Forest Soil   | 2.56 | 0   | 0.8  | 0.88 | 1.1  | 0.22 |

The results indicate that the average gravel content in forest soils of Uvur Zaisan Valley was  $2.02 \pm 2.4\%$ , whereas in Ar Zaisan Valley it was  $0.8 \pm 0.88\%$ , reflecting differences in soil texture among the study sites. The higher gravel content in Uvur Zaisan soils can be attributed to mountain geomorphology, slope position, and soil erosion and degradation processes.

Table 4. Estimated Soil Organic Carbon Stock in Forest Soils of the Green Zone

| No                            | Sampling location  | Depth (cm) | n | SOC Stock (t/ha) |
|-------------------------------|--------------------|------------|---|------------------|
| Uvur Zaisan Valley n Bogdkhan |                    |            |   |                  |
| 1                             | Uvur Zaisan Valley | 0-5        | 3 | 29.78            |
|                               |                    | 5-10       | 3 | 23.27            |
|                               |                    | 10-20      | 3 | 52.32            |
|                               |                    | 20-30      | 3 | 43.30            |
| Ar Zaisan Valley n Bogdkhan   |                    |            |   |                  |
| 2                             | Zaisan Vallye      | 0-5        | 4 | 25.72            |
|                               |                    | 5-10       | 4 | 22.87            |
|                               |                    | 10-20      | 4 | 47.70            |
|                               |                    | 20-30      | 4 | 41.00            |

The results indicate that soil organic carbon (SOC) stocks in the top 0–30 cm layer of forest soils at our study sites were 148.67 t ha<sup>-1</sup> in Uvur Zaisan and 137.29 t ha<sup>-1</sup> in Ar Zaisan. This represents a difference of 11.38 t ha<sup>-1</sup> between the two sites, with Uvur Zaisan exhibiting higher SOC. The elevated SOC in Uvur Zaisan soils corresponds with the greater organic carbon content observed at this location.

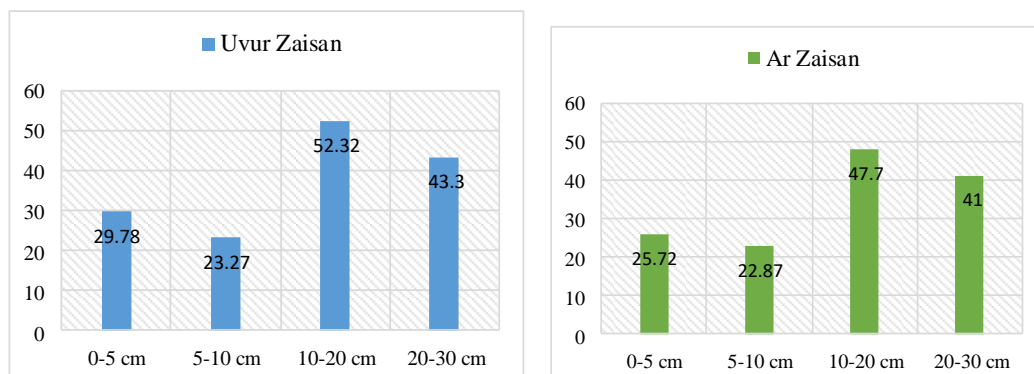


Fig 5 and 6. Soil Organic Carbon Stock (t/ha) in Forest Soils of the Green Zone

Based on the data, the soil organic carbon stock in Uvur Zaisan forest soils was 29.7 t/ha at 0–5 cm, 23.2 t/ha at 5–10 cm, 52.3 t/ha at 10–20 cm, and 43.3 t/ha at 20–30 cm depth. In Zaisan forest soils, the values were 25.7 t/ha (0–5 cm), 22.8 t/ha (5–10 cm), 47.7 t/ha (10–20 cm), and 41.0 t/ha (20–30 cm), respectively.

### Soil Agrochemical Properties and Organic Carbon Content in Green Spaces

In the limited-use green space areas included in the study, the dominant soil type was classified as mountainous dark brown soil.

Table 5. Agrochemical Properties of Soil in Green Space Areas

| Depth (cm)                                    | pH   | Ялзмаг, % | SOC, % | Exchangeable Bases (mg-eq/100g) |    | Nutrient Elements (mg/100g)   |                  |
|-----------------------------------------------|------|-----------|--------|---------------------------------|----|-------------------------------|------------------|
|                                               |      |           |        | Ca                              | Mg | P <sub>2</sub> O <sub>5</sub> | K <sub>2</sub> O |
| <i>Urban Green area in Uvur Zaisan Valley</i> |      |           |        |                                 |    |                               |                  |
| 0-5 cm                                        | 6.80 | 6.50      | 3.77   | 23                              | 6  | 0.81                          | 48               |
| 5-10 cm                                       | 7.16 | 5.36      | 3.11   | 22                              | 4  | 0.63                          | 46               |
| 10-20 cm                                      | 7.27 | 5.03      | 2.92   | 25                              | 14 | 0.55                          | 42               |
| 20-30 cm                                      | 7.47 | 2.58      | 1.50   | 30                              | 14 | 1.06                          | 32               |
| <i>Green Zone in Uvur Zaisan</i>              |      |           |        |                                 |    |                               |                  |
| 0-5 cm                                        | 7.81 | 3.40      | 1.97   | 34                              | 11 | 0.78                          | 51               |
| 5-10 cm                                       | 7.99 | 3.21      | 1.86   | 31                              | 9  | 1.02                          | 68               |
| 10-20 cm                                      | 8.35 | 3.12      | 1.81   | 23                              | 8  | 0.94                          | 58               |
| 20-30 cm                                      | 8.15 | 2.81      | 1.64   | 25                              | 6  | 0.96                          | 38               |

Based on the results, the soil reaction in the green space area of Uvur Zaisan Valley (0–30 cm depth) ranged from slightly acidic to slightly alkaline, with humus content varying between 2.58 % and 6.50 %, and organic carbon content ranging from 1.50 % to 3.77 %.

In contrast, the soil in the green space area of Zaisan Valley showed a reaction from slightly alkaline to moderately alkaline, with humus content between 2.81 % and 3.40 %, and organic carbon content between 1.64 % and 1.97 %.

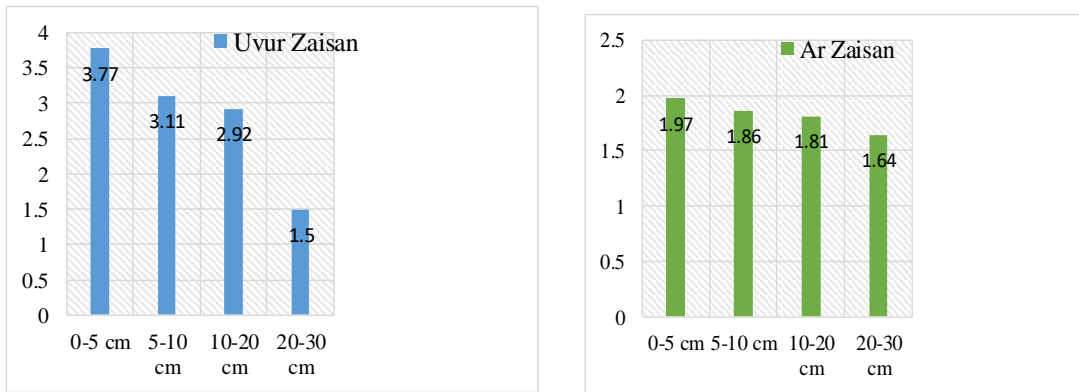


Fig 7 and 8. Soil Organic Carbon Content (%) in Green Space Areas

The results show that soil organic carbon (SOC) stocks in Uvur Zaisan forest soils were 29.7, 23.2, 52.3, and 43.3 t ha<sup>-1</sup> at depths of 0–5, 5–10, 10–20, and 20–30 cm, respectively. In Ar Zaisan forest soils, the corresponding SOC stocks were 25.7, 22.8, 47.0, and 41.0 t ha<sup>-1</sup>. In both sites, SOC stocks were higher in the middle and lower soil layers (10–30 cm), indicating that organic carbon is concentrated in the topsoil and accumulates substantially at relatively deeper layers. This pattern can be attributed to root decomposition, soil moisture, and gravel content at each site. Spatial distribution maps of SOC stocks in Uvur Zaisan and Ar Zaisan soils were generated using ArcGIS 10.5 software with the Interpolation (Kriging) tool in ArcToolbox (Figures 11,12).

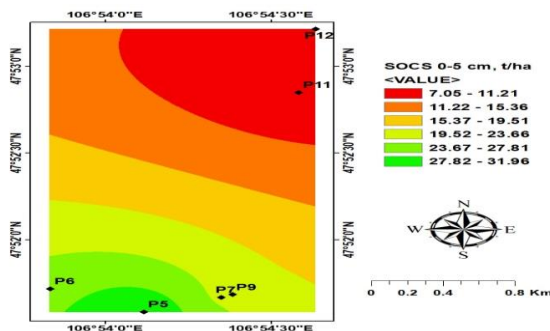


Fig 9. Soil Organic Carbon Stock in the Upper Zaisan Valley (0–5 cm Depth)

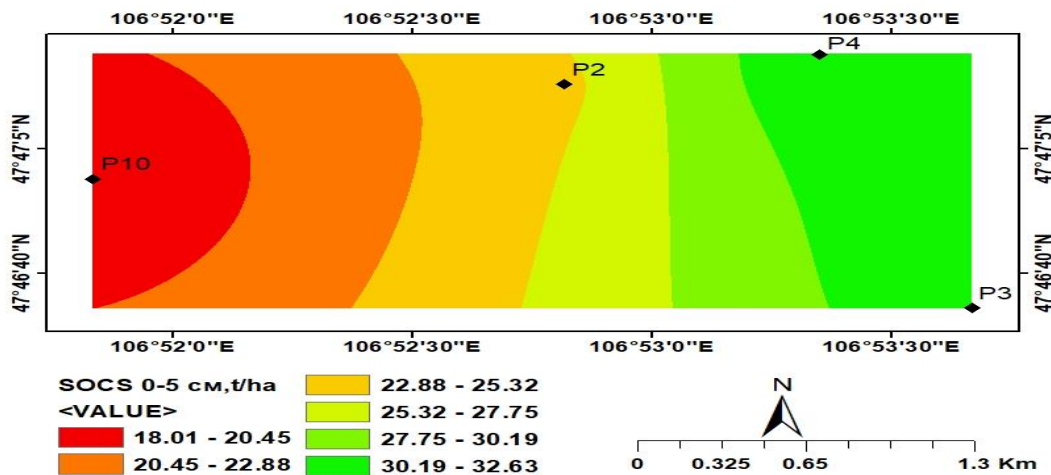


Fig 10. Soil Organic Carbon Stock in the Uvur Zaisan Valley (0–5 cm Depth)

## 4. DISCUSSIONS

According to previous studies on SOC stocks in Mongolia, the average organic carbon content in the top 0–30 cm of soil is approximately 43.0 t ha<sup>-1</sup> [7]. In our study, SOC stocks in forest soils ranged from 137.29 to 148.67 t ha<sup>-1</sup>, and in soils of green spaces from 49.18 to 77.94 t ha<sup>-1</sup>.

Results from studies in the Terej River basin indicate that humus content in taiga spruce soils was 15.3% in the 3–10 cm layer and 7.08% in the 10–30 cm layer [34]. In comparison, our study found that humus content in dark forest soils was 10.94–11.43% at 5–10 cm depth and 7.02–7.33% at 20–30 cm depth.

These findings demonstrate that key agrochemical properties of soils in the Uvur Zaisan and Ar Zaisan valleys decrease with depth, with higher concentrations in the upper soil layers. In particular, SOC and humus content were highest in the 0–5 cm layer, confirming that organic matter accumulation is predominantly concentrated in the topsoil. This is consistent with previous studies showing that land use on sloping Zaisan sites leads to soil degradation and annual humus losses of several tens of t ha<sup>-1</sup> [36].

Additionally, our results indicate that soils in Ar Zaisan were slightly acidic with relatively higher potassium content, whereas Uvur Zaisan soils were more acidic with higher humus and SOC content. Land use, geomorphological conditions, and variations in vegetation cover likely contribute to these differences. The observed SOC variability is a key factor directly affecting soil fertility and ecosystem stability, as also highlighted by Batkhuyag et al. (2023) [35].

For comparison, in afforested soils in Ireland, SOC stocks in the 0–100 cm layer range from 162 to 416 t ha<sup>-1</sup> depending on soil characteristics [37]. In our study, SOC stocks in the top 0–30 cm of forest soils averaged 137.29–148.67 t ha<sup>-1</sup>.

## 5. CONCLUSION

First, Soils in the Uvur and Ar Zaisan valleys are moderately to slightly acidic, with humus and soil organic carbon (SOC) content ranging from 4.0 to 14.1%. SOC content in Uvur Zaisan soils (4.7–8.2%) was higher than in Ar Zaisan soils (4.0–7.2%), reflecting differences in land use characteristics. These findings indicate the urgent need to protect and restore soil fertility and carbon stocks."

Second, SOC stocks in the top 0–30 cm of forest soils were 148.67 t ha<sup>-1</sup> in Uvur Zaisan and 137.29 t ha<sup>-1</sup> in Ar Zaisan. These values are 94.29–105.67 t ha<sup>-1</sup> higher than the national average for topsoil at a depth of 0–30 cm in Mongolia (43.0 t ha<sup>-1</sup>). This highlights both the capacity of forest soils to accumulate substantial carbon and the site-specific differences observed in the study. Forest soils therefore play a critical role in carbon cycling and ecosystem stability.

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### AUTHOR'S INTRODUCTION


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