SOIL CHARACTERISTICS AND THEIR INFLUENCES ON CO₂ EFFLUX IN A TROPICAL URBAN LAWN

Lim Kang Yong Benjamin (A0096780R)
Supervisor: Dr. Amy Choong Mei Fun (Department of Biological Sciences, NUS)
Co-supervisor: Dr. Erik Velasco (Singapore-MIT Alliance for Research and Technology)

Introduction

Soil respiration ($F_r$) can be an important contributor to the CO₂ budget in urban landscapes, especially in tropical cities with extended green areas (Velasco et al., 2013). Warm and moist soils enhance CO₂ production by roots and microorganisms. Soil characteristics such as pH, total organic carbon (TOC), bulk density, porosity, and particle size distribution influence CO₂ production and diffusion in the soil matrix (Pouyat et al., 2010). Typical urban soils are highly disturbed due to land use change, and hence exhibit high degrees of spatial heterogeneity in soil characteristics.

One-third of Singapore contains urban vegetation, and $F_r$ is expected to be an important source of CO₂ to the atmosphere, yet it has been neglected in climate change mitigation policies. This study investigates the aforementioned soil characteristics in a representative urban lawn of Singapore as part of the ongoing research project "Urban Carbon Sequestration" coordinated by the Singapore-MIT Alliance for Research and Technology.

Objective

This study aims to evaluate the spatial heterogeneity of soil characteristics important for soil CO₂ efflux across a lawn that has been relatively undisturbed for 4 decades in a residential neighbourhood of Singapore.

Materials and Methods

The study site in Telok Kurau (Fig. 1) has a rich history: fishing village (1960s) → primary school (1967) → hostel (2000) → vacant state land (2011-present). Soil samples were collected in the lawn (46 m by 32 m) via a stratified random method at 27 sampling points and 8 different depths (0-5 to 125-130 cm) (Fig. 2). With the exception of bulk density and porosity (Fig. 3), all soil characteristics (pH, organic carbon, particle size distribution) were analyzed in the laboratory. A heterogeneity test for each characteristic was performed using ANOVA.

Results and Discussion

![Image](https://via.placeholder.com/150)

<table>
<thead>
<tr>
<th>TOC (%)</th>
<th>Depth: 15-20 cm</th>
<th>Depth: 75-80 cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 2.5</td>
<td><img src="https://via.placeholder.com/150" alt="Image" /></td>
<td><img src="https://via.placeholder.com/150" alt="Image" /></td>
</tr>
<tr>
<td>2.5-5.5</td>
<td><img src="https://via.placeholder.com/150" alt="Image" /></td>
<td><img src="https://via.placeholder.com/150" alt="Image" /></td>
</tr>
<tr>
<td>0.5-1.5</td>
<td><img src="https://via.placeholder.com/150" alt="Image" /></td>
<td><img src="https://via.placeholder.com/150" alt="Image" /></td>
</tr>
<tr>
<td>0-0.5</td>
<td><img src="https://via.placeholder.com/150" alt="Image" /></td>
<td><img src="https://via.placeholder.com/150" alt="Image" /></td>
</tr>
</tbody>
</table>

Fig. 4: Horizontal variation of total organic carbon (TOC) in each soil depth. The numbers 1-28 indicate the sampling cells and they apply for all soil depths. Cell 14 contains the instrumentation and was hence excluded from sampling.

![Image](https://via.placeholder.com/150)

Fig. 5: Vertical variation of TOC at each sampling point.

Organic carbon was highest (1-2%) at 0-10 cm and low (<1%) at 15-130 cm (Fig. 5). Urban soils with grass have more organic carbon in the upper layers (Biasioli et al., 2006). Horizontal heterogeneity (Fig. 4) in most soil layers suggests potential for spatially varied CO₂ efflux.

![Image](https://via.placeholder.com/150)

Fig. 6: Particle size distribution, bulk density, and porosity.

Clay (<2 µm) and silt (2-63 µm) were concentrated in the top 30 cm while sand (63-2000 µm) was concentrated at 50-130 cm (Fig. 6). The compactness of silt and clay hinders CO₂ diffusion and escape (Craul, 1985) from the soil surface.

Bulk density was atypically low while porosity was relatively high for urban soils (Fig. 6) due to absence of human compacting factors. This may ease CO₂ diffusion and escape.

Urban soils are typically alkaline (Craul, 1985). On the contrary, observed pH in this study was slightly acidic (4.5-6) due to absence of major construction works for 4 decades. pH was horizontally heterogeneous in 0-10 cm and vertically homogeneous overall.

Conclusions

Observed soil characteristics were heterogeneous like other urban soils. Variations and unpredictability of these characteristics suggest the potential for differential CO₂ efflux across urban spatial scales.

Acknowledgements

This study was supported by the NUS Department of Biological Sciences and the National Research Foundation through the Singapore-MIT Alliance for Research and Technology. The chemical determinations were conducted in the GeoLab of the NUS Department of Geography. We appreciate the Singapore Land Authority for granting access to the study site.

References