Assessing Soil Carbon Dynamics in Amended Urban Farms in Fort Worth Using Thermal Analysis

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1. ABSTRACT

Fort Worth, the fastest-growing city in Texas, contains many vacant land plots suitable for urban agriculture—an opportunity to address local food deserts. However, unsustainable farming can degrade soil organic carbon and reduce productivity. This study assessed soil carbon dynamics in a food waste compost–amended urban farm in Fort Worth. Experimental plots, including compost-amended and control treatments (triplicated), were established and monitored monthly from January 2023 to July 2024. Thermo-gravimetric Analysis (TGA) was used to calculate the recalcitrance index (R50), indicating carbon stability. Results showed compost-treated soils had more stable carbon and structured lignin degradation. In contrast, untreated soils exhibited unstructured decomposition and faster carbon loss. Compost enhances soil health and carbon cycling, and future research should explore combining compost with cover crops to maximize carbon sequestration and microbial activity in urban farming systems.

2. BACKGROUND

Food Security

⇒In 2023, over **18 million** households in the U.S. struggled with food security (Rabbitt et al., 2024)

Figure 1: Food security criteria and its level (Tam et al., 2014)

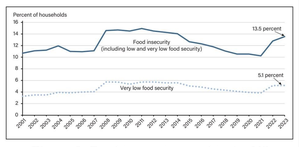


Figure 2: Food insecurity trend in the US (Rabbitt et al., 2024)

Food Desert

⇒**Over 33%** of the population lives more than **a mile away** from a supermarket (American Inequality, 2024).

⇒In the US, **23.5 million people** reside in food deserts (American Inequality, 2024).

⇒**Over 250,000** people in **Fort Worth** living in a food desert (Project, 2020)

⇒According to the North Central Texas Council of Governments (NCTCOG), Fort Worth has over **70,000 acres** vacant developable land

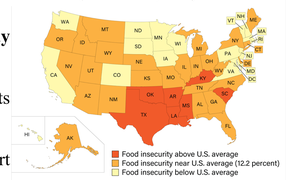


Figure 3: Prevalence of food insecurity, average 2021-23 (Rabbitt et al., 2024)

Sustainable Urban Farming

⇒**Focuses**: Eco-friendly farming practices

⇒**Aim**: Minimize waste, improve soil health, and enhance biodiversity

⇒**Example**: Using **Food Waste Compost** as amendment.

⇒**Benefits**: Reduces landfill waste and methane emission, reduces fertilizer use, promote circular economy, etc.

Figure 4: Urban farming and its benefits (Lal, 2020)

Question

How much carbon sequestration potential can urban farms achieve by using food waste compost as soil amendments?

3. OBJECTIVE

The objective of this research is:

⇒To identify the **recalcitrance** and **carbon sequestration potentiality** of urban farms that uses food waste compost as soil amendment.

4. METHODOLOGY

Study Area

Opal farm, situated on the bank of Trinity River at United Riverside, Fort Worth, TX 76111

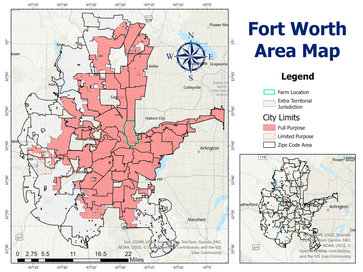


Figure 5: Farm Location

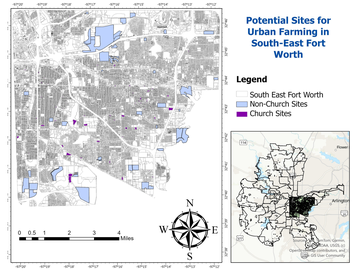
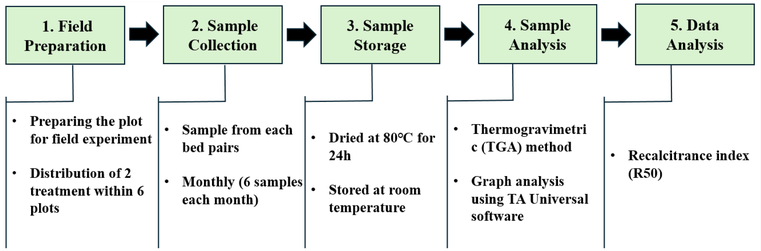


Figure 6: Distribution of potential sites in the South-East region of Fort Worth

Study Methods



Bed Type: Conventional Tillage; **Trellis Type:** Handy Panels (in situ); **Irrigation:** Drip (in situ); **Walkways:** woodchip (~1.5"); **Number of Beds:** 12, (10' x 2.5'); **Crop:** Celebrity Tomato; **Number of Treatments: 2**; 2 beds (pairs) per treatment area; 3 x 2 treatment areas per plot.

- **Thermo-Gravimetric Analysis (TGA)**

Weigh 50mg sample → **Place them in an alumina TGA crucible** → **Air flow rate of 100mL/min** → **Ramp temperature to 900°C at 10°C/min** → **Analyze the graphs using TA Universal software**

Carbon Sequestration Potentiality

Recalcitrance Index (R50) will be used for evaluating the recalcitrance and carbon sequestration potentiality of each sample (Harvey et al., 2012),

$$R_{50} = T_{50,x} / T_{50,graphite} \quad \text{..... (Eq. 1)}$$

where $T_{50,x}$ is the temperature at 50% oxidation/volatilization of sample x and

$T_{50,graphite}$ is the temperature at 50% oxidation/volatilization of Graphite.

5. RESULTS AND DISCUSSION

Recalcitrance Index and Derivative Weights

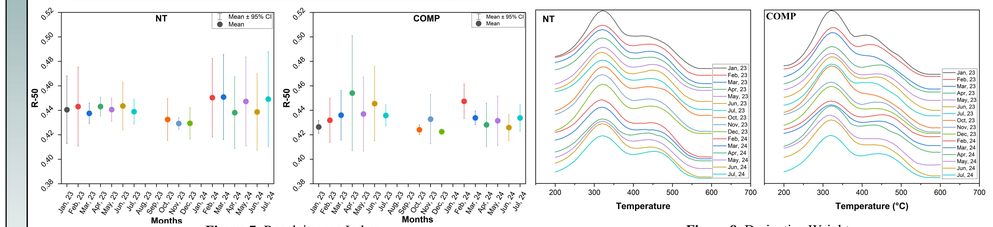


Figure 7: Recalcitrance Index

Figure 8: Derivative Weights

⇒NT builds up more recalcitrant carbon post-2023, indicating **potential for long-term sequestration** but limited nutrient cycling.

⇒COMP maintains **moderate, fluctuating R50**, supporting **active microbial processes and carbon turnover**.

⇒COMP enhances **carbon cycling and soil function**, while NT favors **carbon storage with limited biological benefit**.

⇒For **urban farming**, COMP offers a **better balance between carbon sequestration and soil productivity**.

Key Findings from 2D Perturbation Analysis

NT (No Treatment):

⇒***Lignin* degraded earlier** than hemicellulose (440, 203).

⇒***Cellulose*** degradation occurred both before and after hemicellulose peaks (320, 203 and 386, 226), suggesting **inconsistent decomposition** patterns.

Comp (Food Waste Compost):

⇒***Cellulose*** showed both early and late degradation relative to hemicellulose, but more defined patterns than NT.

⇒***Lignin*** primarily degraded **after cellulose and hemicellulose** (e.g., 470, 377; 480, 200), with some early responses (528, 311), indicating **complex** and **stabilized** breakdown dynamics.

Figure 9: 2D Perturbation Analysis

Table 1: Summary of Noda's Rules for Interpreting Synchronous and Asynchronous Analysis (Harvey et al., 2016)

Asynchronous Ψ (v_1, v_2)	Synchronous Φ (v_1, v_2)	Interpretation
	+	The intensity of v_1 and v_2 are changing in the same direction, i.e. increasing or decreasing together
	-	The intensity of v_1 and v_2 are changing in the opposite direction
+	+	The changes at v_1 are occurring predominantly before that at v_2
-	+	The changes at v_1 are occurring predominantly after that at v_2
+	-	The changes at v_1 are occurring predominantly after that at v_2
-	-	The changes at v_1 are occurring predominantly before that at v_2

What Does This Mean?

⇒**Compost-treated soils** exhibit **more ordered and delayed lignin degradation**, contributing to **stable organic carbon pools**.

⇒Food waste compost supports **structured carbon breakdown**, improving **carbon use efficiency** and **soil health**.

⇒In contrast, NT soils show **overlapping and less predictable degradation**, potentially leading to faster carbon loss.

6. CONCLUSION

Compost-treated soils promote structured degradation of lignin and cellulose, leading to enhanced carbon cycling, moderate recalcitrance, and improved soil health. This treatment supports active microbial processes and gradual organic matter turnover, offering a balanced approach to carbon sequestration and nutrient availability. In contrast, no treatment (NT) results in unstructured degradation patterns and higher recalcitrance, indicating potential long-term carbon storage but limited biological activity. To further optimize soil carbon dynamics in urban farming, future research should investigate the combined use of food waste compost and cover crops. This integrated strategy may enhance microbial activity, improve soil structure, and maximize both productivity and sustainability.

SCAN ME FOR REFERENCES

Thanks for your attention