Exploring urban soil ecology: Influence of the length of urbanization period on soil chemical properties and nematode community

Sunjeong Park(1, 2), Brian B. McSpadden Gardener(1,3), and Parwinder S. Grewal(1,2)

1. Environmental Science Graduate Program, 2. Department of Entomology, and 3. Department of Plant Pathology, The Ohio State University-OARDC, Wooster, OH

Abstract

Urban development causes substantial disturbance to the soil ecosystem. The initial disturbance, coupled with subsequent anthropogenic inputs including fertilizers, pesticides, atmospheric deposits, contaminants and heat, have the potential to produce unique soil properties and soil food web in urban ecosystems. Therefore, the main objective of this study was to investigate the impacts of the length of urbanization period on soil chemical properties and nematode community. Urban boundaries from 1920's (old), 1960's (middle) and 2000's (new) were identified for three cities in northeast Ohio; Canton, Massillon and Wooster. From each urban age ring, one public school site constructed within the defined time period was selected. Major soil nutrient pool sizes and nematode community composition were assessed. Most interestingly, the longer the urbanization period the higher was the total soil C and N in Massillon and Wooster (P<0.01 for each). On the contrary, soils from newly developed sites in Canton contained higher total C and N. It is likely that the difference in Canton resulted from different turf management practices such as compost amendment indicated by dark, light soil. Nematode abundance and genus-level richness were also greater in old sites than those in new areas in Massillon and Wooster (P-values<0.10). More strikingly, the distribution of nematodes among 12 dominant genera significantly varied with urban age in all three cities (P-values<0.001). We conclude that initial urban development substantially disturbs soil nematode community which recovers overtime at least in the nematode abundance and genus richness.

Introduction

- Urban areas provide unique opportunities to study anthropogenic impacts on soil ecosystem.
- Urbanization imposes two very different disturbances on soil; more drastic physical disturbance during initial urban development and long-term alternation of soil chemistry through chemical inputs.
- The response of soil organisms to the human-induced changes in urban areas are mostly unknown.

Hypothesis

- The length of urbanization period would have significant impact on soil chemical properties and nematode community, and the impact would be different in roadside and interior lawns.

Objectives

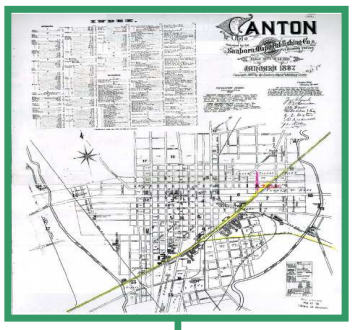
- Compare soil chemical properties and nematode community along urban age gradient in roadside and interior lawns.

Methods

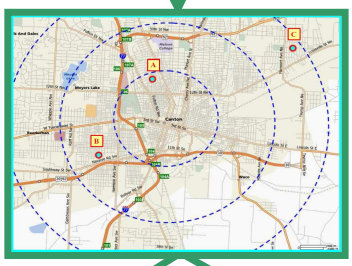
TABLE 1. Year of construction for selected public schools within each urban age ring

Location	Canton	Massillon	Wooster
	Year of construction		
Old	1921	1910's	1870
Middle	1956	1964	1949
New	1998	2005	1996

Fig. 1. Flow chart of methodology



- City boundaries from 1920's (old), 1960's (middle) and 1990's (new) were identified in Canton, Massillon and Wooster, Ohio.



- One public school built within the defined period was identified, within each urban age ring, (**Table 1**).
- A: old, B: medium and C: new

- Two roadside and two interior lawns were selected at each school site.
- Five separate soil cores were collected on a transect in the middle of each plot.

- Nematodes were extracted using Baermann funnel, counted and identified to genus-level.
- Nematode community indices were calculated according to Ferris et al. (2001).
- Soil chemical properties (pH, SOM, total C, N, P, K, Ca, Mg, CEC) were measured at the STAR lab.

Results

Soil chemical properties

- The longer the urbanization period, the higher was the total soil C and N in Massillon and Wooster (P<0.01 for each, **Fig. 2 & 3**)
- On the contrary, in Canton, soils from newly developed sites contained higher total C and N.
- Soil pH and Ca content were significantly higher in old and middle aged urban sites than new in all three cities (P<0.10).

Soil nematode community

- Nematode abundance and genus richness were greater in old sites than those in new areas in Massillon and Wooster (P-values<0.10, **Fig. 4 & 5**)
- The distribution of nematodes among 12 dominant genera significantly varied with urban age in all three cities (chi-square test, P-values<0.001).
- Bacteriovre *Rabditis*, *Cephalobus* and plant feeder, *Helicotylenchus* were more abundant in old and middle aged sites than new urban areas (**Table 2**).

Discussions

- Differences in Canton city are likely due to different turf management practices such as compost amendment indicated by dark, light soil.
- Nematode faunal analysis did not indicate any differences in soil food web structure and enrichment with the urban age. This could be due to the dominance of basal nematode group which indicate the disturbed food web.

Conclusions

- **Total soil C and N were significantly higher in old , middle aged sites than newly developed areas in in Massillon and Wooster.**
- **Nematode abundance and genus richness were also significantly higher in old and middle aged sites than new ones in Massillon and Wooster.**
- **Distribution of the 12 dominant genera significantly differed with urban age.**
- **Soil nematode community disturbed by initial urban development recovers over time at least in abundance and genus richness.**

Fig. 2. Total C content (%) in soil along the urban age

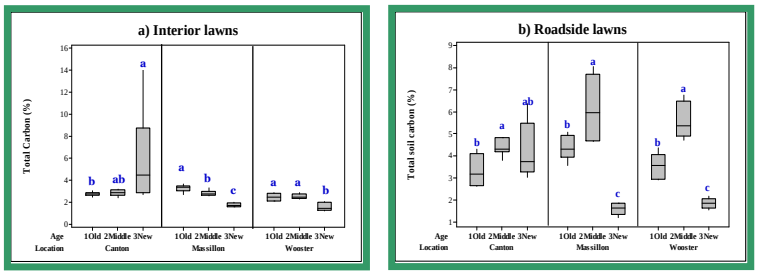
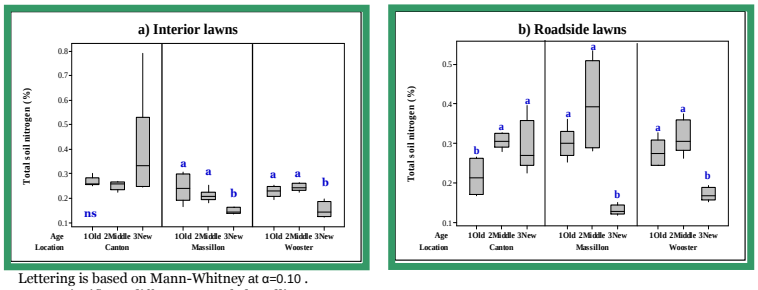


Fig. 3. Total N content (%) in soil along the urban age



Lettering is based on Mann-Whitney at α=0.10 .
NS: no significant difference, Kruskal-Wallis test at α=0.10 .

TABLE 2. Abundance of *Rabditis*, *Cephalobus* and *Helicotylenchus* along the urban age

		Canton (I)	Canton (R)	Massillon (I)	Massillon (R)	Wooster (I)	Wooster (R)
Urban Age		Median number of nematodes					
Rhabditis	Old			15.5 **a**	14.5 **a**	22.5 **a**	
	Middle	NS	NS	5.0 **b**	10.5 **a**	6.0 **b**	NS
	New			1.0 **c**	1.0 **b**	13.5 **a**	
Cephalobus	Old		1.0 **b**	11.0 **a**	9.5 **a**	16.0 **a**	
	Middle	NS	12.0 **a**	4.0 **a**	10.5 **a**	1.0 **b**	NS
	New		2.5 **b**	0.0 **b**	0.5 **b**	1.5 **b**	
Helicotylenchus	Old	2.0 **b**		22.5 **a**		3.0 **a**	
	Middle	9.5 **a**	NS	1.0 **b**	NS	10.0 **a**	NS
	New	3.0 **ab**		N.A*		1.0 **b**	

I: interior lawns,
R: roadside lawns

Lettering is based on Mann-Whitney at α=0.10

NS: no significant difference

* unable to perform Mann-Whitney, because all the observations had same value (0).

Fig. 4. Abundance of nematodes along the urban age

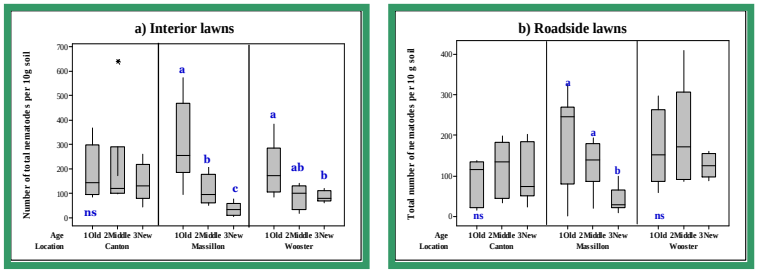
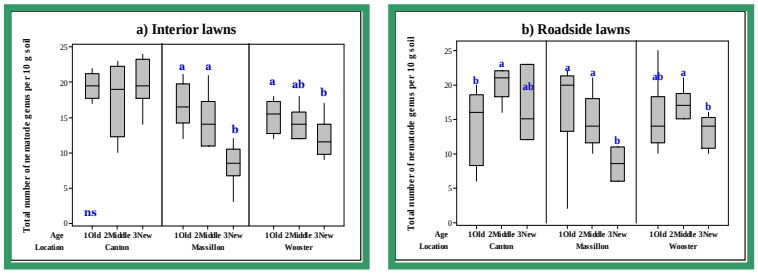


Fig. 5. Genus-level richness of nematodes along the urban age



Lettering is based on Mann-Whitney at α=0.10 .
NS: no significant difference, Kruskal-Wallis test at α=0.10 .

References

- Ferris et al. 2001. A framework for soil food web diagnostics: extension of the nematode faunal analysis concept. Applied Soil Ecology 18:13-29

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