Nitrogen and Phosphorus Concentrations in the Drilosphere in A Long-Term No-Till Agroecosystem

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Introduction

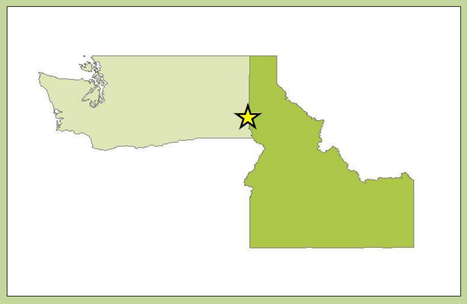
Earthworms significantly alter soil chemical, physical, and biological properties and are commonly referred to as ecosystem engineers. Burrowing and feeding activity contributes to organic matter incorporation. The "drilosphere" is the zone of soil that is directly influenced by earthworm activity and includes the burrow wall and surrounding soil. Past research has shown the drilosphere to be enriched in total carbon, nitrogen, and ammonium. The drilosphere has traditionally been defined as extending 2 mm from the burrow wall (Bouche, 1975). However, recent publications suggest that the drilosphere may extend at least 8 mm from burrow walls. A better understanding of the drilosphere may help determine the role that earthworms play in nutrient availability and soil health.

Objectives

The objectives of this study were to 1) determine if a significant drilosphere effect could be detected on C, N and P concentrations in an agricultural soil in the Palouse region of Northern Idaho and Eastern Washington and 2) estimate how far the drilosphere extends away from the burrow wall relative to each element.

Study Site

- Study site at Cook Agronomy Farm, a USDA Long-Term Agroecosystem Research site in Whitman County, WA
- Earthworm species include *Lumbricus terrestris* and *Aporrectodea trapezoides*
- The main soil types are eroded Palouse silt-loam and Thatuna silt loam



- Two pedons examined on summit and toe-slope
- MAT = 8.3°C MAP = 517 mm

Methods

1.5 mm pin heads

- Eight burrows were identified and exposed up to > 1 m depth
- Samples were collected at 4 distances from burrows (0-3, 3-6, 6-9, and 9-12 mm) and a bulk soil collection (>25 mm). Samples were homogenized along the full burrow length, air dried, and ground
- Soil samples were analyzed for Total Inorganic Nitrogen (TIN), total carbon and nitrogen, and Mehlich-3 extractable phosphorus
- These data were analyzed using a Generalized Linear Mixed Model (GLIM) assuming beta distribution with a Logit line function (Stroup, 2014). Distance was considered a fixed effect and burrows a random effect.

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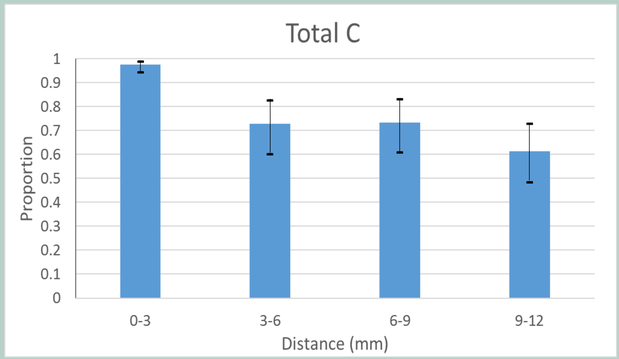
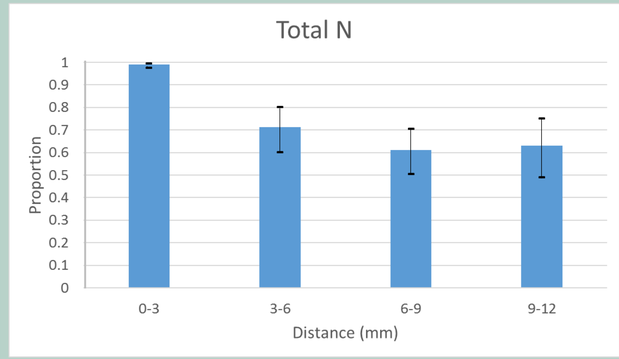
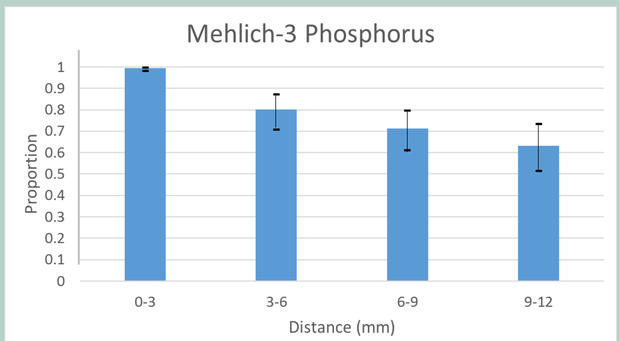
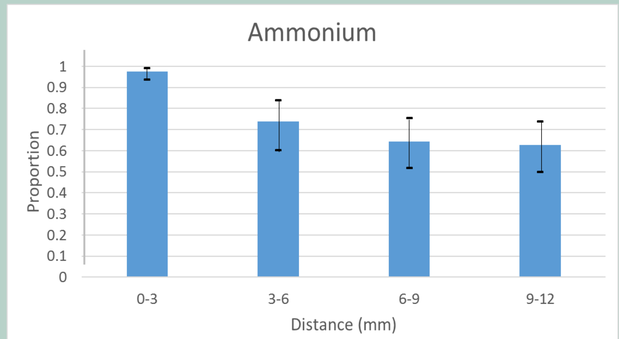
Results and Discussion





All figures are displayed as proportions of the highest detected concentration per burrow. Total carbon and nitrogen concentrations generally exhibited decreasing trends with distance from burrow walls. Earthworm inputs of organic matter include litter incorporation, casting, and mucus deposition on burrow walls. Due to high variability between burrows, statistical differences between distances could not be identified.





Extractable phosphorus concentration decreased in a linear fashion from the burrow wall, with the 0-3 mm distance being significantly higher than the 6-9 mm distance. A similar but non-significant trend was observed in ammonium. Enhanced P availability in the drilosphere may be ecologically important due to the constraints on P bioavailability within the soil-plant system. Earthworm burrows are hotspots of microbial activity, and plant roots are often found in burrow channels. This zone of increased biological activity hosts bacteria that transform nutrient species and mineralize organic matter. The mechanisms of nutrient mineralization and transformation are the topic of continued study.

The trends observed above support previous studies which found evidence of earthworm effects at distances > 8 mm. Phosphorus had not been considered in previous studies. These results are promising given that sampling agricultural field sites introduces greater variability and heterogeneity. The study site is under active crop rotation and receives frequent fertilization. This preliminary study used a small sample size (n=8). Additional samples will improve the ability to detect changes in nutrient concentration with proximity to earthworm burrows.

Burrow age and root density may be important factors in drilosphere nutrient dynamics. Further investigation into drilosphere extent could lead to development of a model quantifying earthworm-affected soil at larger spatial scales and total influence on nutrient availability.

Summary

- Total carbon and nitrogen, phosphorus, and ammonium all showed decreasing trends with distance from burrow walls
- High variability under field conditions affected statistics, but nutrient trends are consistent
- Future research should investigate age and root presence on nutrient concentrations in the drilosphere

Acknowledgements

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