Assessing the effects of Lake Dredged Sediments on Soil Health: Agricultural and Environmental Implications in Northwestern Ohio

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Research Goals

Using a greenhouse approach…

1. Identify the appropriate native top soil to dredged material ratio to achieve the best crop yield.

2. Determine changes in soil health when a legacy P farm soil is amended with dredged material.

3. Determine nutrient and metal release into soil solution.

4. Determine metal and microcystin bioaccumulation in crop grains.

5. Understand the impacts of dredged material on microbial populations
Soil Health

**Biological Health**
- Microbial Biodiversity
- Macroinvertebrates Dynamics
- Nutrient Cycling
- Organic Matter Degradation
- Pesticide Detoxification
- Pathogen Suppression

**Chemical Health**
- pH
- Nutrients Content
- Cation Exchange Capacity
- Pollutants Immobilization
- Organic Carbon Content
  - Aromaticity
  - Recalcitrance

**Physical Health**
- Bulk Density
- Texture
- Porosity
- Compaction
- Water Holding Capacity
- Infiltration
Greenhouse Experimental Setup

100% soil
10% dredged
90% soil
20% dredged
80% soil
100% dredged

No Plants

Soybean Plants

- Quadruplets
- 32 buckets
Sample Characterization

Greenhouse Experiments

Solid Characterization – initial and final
- Soil – TC, IC, TOC, TN, TP, cations and metals, soil test, microbial community composition
- Grains – crop yield, TC, TN, TP, metal and microcystin bioaccumulation
- Plant tissue - below biomass, TC, TN, TP

Percolated Solution - characterization during growing season
- TOC, TN, TP, PO$_4$, NO$_3$, pH, EC, cations and metals
Effects of Dredged Sediment Amendment on Soil Health
Dredged sediments slightly increased soil pH, which can be beneficial for crops adapted to slightly alkaline soil pH conditions.
The addition of dredged sediments increased significantly SOC concentrations in farm soils ($p<0.05$).

High SOC benefits soil health by improving soil fertility, soil structure, water holding capacity, water percolation, soil resistance to erosion, nutrient retention, and crop productivity.
Dredged sediments substantially increased cation exchange capacity (CEC) increasing macronutrient bioavailability.

- Mainly controlled by Ca content.
• The addition of dredged sediment to the farm soil induced a decrease in P in this legacy P farm soil.

• P levels decreased towards more agronomic values (dilution effect).
Average bulk density showed a slight decrease with increasing dredged sediment ratios; however, the increase was not significant (p>0.05).

Lower bulk density affects the function of the soil by allowing greater infiltration, increasing soil porosity and water capacity.
Results and Implications

Effects of Dredged Sediment Amendment on Crop Yield and Biomass
The amendment of farm soil with dredged sediments did not show any significant changes to soybean yields or root biomass. However, the averages of these parameters slightly increased as the dredged sediment ratio increased.
Greater amounts of finer roots and root hairs.
Nutrient and Heavy Metals Loss into Waterways
We observed a decreased in PO$_4$ loads at the soybean growth stage R3, indicating a potential larger used of these compounds as the plant is starting to produce pods. P is part of the DNA make up.
• We observed a large decreased in NO$_3$ loads at the soybean growth stage R3, indicating a potential larger used of these compounds as the plant is starting to produce pods. N is part of the DNA make up.

• Overall, amending farm soil with dredged sediments at various ratios did not significantly affect the export of nutrients (TP, PO$_4$, TN, NO$_3$, K, Mg, and Ca) into waterways.
• Arsenic and lead concentrations are above the recommended EPA drinking water standards. However, the concentrations are similar for that of the local soil.
• Cr, Cu, Ni, and Zn concentrations meet the recommended EPA drinking water standards.
Contaminants Bioaccumulation and Export into Waterways
Heavy Metal Bioaccumulation in Soybean Grains

- Overall, no apparent preferential bioaccumulation of heavy metals in the grains.
Collection time – soil and dredged sediments

GreenWater Laboratories
205 Zeagler Drive
Suite 302
Palatka FL 32177
Ph: (386) 328-0882
Fax: (386) 328-9646

Tested on: 1/25/2019
Method: Enzyme-Linked Immunosorbent Assay (ELISA)
Analyzer: Microcystins/Nodularins
Analyzed by: Kamil Glisilk

<table>
<thead>
<tr>
<th>Sample ID/ [Extract]</th>
<th>Sample Weight (g)</th>
<th>Sample Value, ng/mL</th>
<th>Assay Value, ng/mL</th>
<th>Dilution Factor</th>
<th>Avg. LF8 Recovery</th>
<th>Avg. LF5M Recovery</th>
<th>Final Concentration (ng/g)</th>
<th>Average ppb (ng/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FS100A0702 0.50</td>
<td>0.10</td>
<td>0.17</td>
<td>1</td>
<td>94%</td>
<td>100%</td>
<td>1.7</td>
<td>1.60</td>
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<td>1/2/2019</td>
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<td>(100% Farm Soil)</td>
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<tr>
<td>DM100A0702 0.50</td>
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<td>0.34</td>
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<td>103%</td>
<td>3.4</td>
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<tr>
<td>(100% Dredged)</td>
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</table>

LOD/LOQ = 1.5 ng/g
LF8 = 1.0 ng/mL MCLR
ND = Not detected above LOD/LOQ
LF5M = 100 ng/g MCLR

Submitted by: Amanda Foss, M.S.
Date: 1/25/2019

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### Summary of Results

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>Total Adda MCs/NODs (MMPB) ng/g</th>
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<tbody>
<tr>
<td>(100% Farm)</td>
<td>S0508SMC</td>
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<tr>
<td>(10% DM:90 FS)</td>
<td>S1316SMC</td>
</tr>
<tr>
<td>(20% DM:80% FS)</td>
<td>S2124SMC</td>
</tr>
<tr>
<td>(100% Dredged)</td>
<td>S2932SMC</td>
</tr>
</tbody>
</table>

**MRL (ng/g):** 5.0  
**Analyst Initials:** AF  
**Date Analyzed:** 11/15/19

### Interpretations:
Total Adda MCs/NODs were not detected in the submitted samples above 5 ng/g (ppb).

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- No preferential bioaccumulation of microcystin in the grains.

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*The results in this report relate only to the samples listed above. This report shall not be reproduced except in full without written approval of the laboratory.*
Microbial Diversity
Dredged material is rich in diverse bacterial populations
Bacterial communities converge in a shared environment
Plants play a more important role than soil types in shaping rhizosphere microbiomes.
Agricultural Implications

• Increasing the dredged sediment ratio showed proportional increases in total organic carbon, cation exchange capacity (CEC), calcium and pH.

• Conversely, the increase in dredged sediment decrease phosphorous in this P legacy farm.

• Average bulk density decreased with increasing dredged sediment ratios.

• Dredged material from Lake Erie has high bacterial diversity.

• Plants play a more important role than soil types in shaping rhizosphere microbiomes.

Environmental Implications

• Dredged sediments can be a viable fertilizer source.
  • The use of synthetic (e.g., urea, monoammonium phosphate) and organic (e.g., manure, biosolids) fertilizers can improve crop growth but also induce unintended detrimental effects to the water quality of freshwater systems.

• Dredged sediment amendment did not increase the nutrient export into waterways.
Thanks!

Questions