Brownfields to Community Gardens - Can it be done?

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Background

What is a brownfields?

Vacant, abandoned property, the reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant.
Brownfield examples

- Vacant residential lots
- Abandoned residential properties next to industrial facilities
- Abandoned properties next to rail lines
- Former school buildings
- Abandoned gas stations
- Abandoned grain elevators
- Former manufacturing facilities
Small Scale Food Production Trends

• 6.8% increase in farmers markets between 2006 and 2008 (USDA)

• More than 18,000 community gardens in the U.S. and Canada (ACGA)

• In 2008, there were appr. 4,600 farmers markets in the U.S. (USDA)
From Brownfields to Community Gardens: Benefits

• Nutrition and food security
• Exercise - a preferred form of exercise across age, gender, and ethnicity
• Mental health - Working with plants and in the outdoors
• Community Health: Building Safe, Healthy, and Green Environments
• Social Life in Urban Neighborhoods - trust, civic engagement, the development of community leaders, and the sharing of goods, services, and information
K-State Project: Gardening Initiatives at Brownfields sites

Work with select community–based gardening initiatives to evaluate uptake of heavy metals and other contaminants by food crops

Develop recommendations for soil preparation and corrective/protective actions to address potential risk of soil contaminants
Site Selection Criteria

• Brownfields site
• About 2,000 ft$^2$
• Intended for community gardening activities
Process

• Establish site history
• Screening and collect soil samples
• Best management practices (adding soil amendments, raised beds)
• Continuous monitoring: soil and produce
• Training and technical assistance to participating community organizations (sample collection, site evaluation, etc.) throughout
Project Goals

• Enhance the capabilities of gardening/farming initiatives to produce crops locally without potentially adverse health effects to the grower or the end consumer

• Contribute to the meaningful revitalization of brownfields sites in a sustainable manner
Project Goals (cont.)

• Increase confidence in urban food production quality

• Provide resources for producers, urban land managers, local and state government, and extension agents to implement proposed BMPs for the detection and mitigation of potentially harmful substances in soils on brownfields sites
Washington Wheatley
Kansas City, MO
Washington Wheatley
Kansas City, MO
Initial Steps at Washington Wheatley

- Soil screening (in-situ)
  - Using handheld X-ray fluorescence (XRF)

- Soil sampling for laboratory verification
Washington Wheatley Total Lead and Chlordane 2009

Legend
- all_from_gps_82808
- Chlordane/DDT/DDE Samples
- XRF Samples

Total Pb Concentration (mg/kg)
- 58 - 80
- 80 - 118
- 118 - 151
- 151 - 206
- 206 - 305

Kansas State University
Soil Test Results:
General soil parameters

Sample collection date: April 9, 2009

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>pH</th>
<th>Mehlich 3 P</th>
<th>K</th>
<th>NH$_4$-N</th>
<th>NO$_3$-N</th>
<th>OM</th>
</tr>
</thead>
<tbody>
<tr>
<td>9S</td>
<td>6.6</td>
<td>130</td>
<td>624</td>
<td>53.6</td>
<td>73.2</td>
<td>3.9</td>
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<tr>
<td>9D</td>
<td>6.6</td>
<td>93</td>
<td>455</td>
<td>9.6</td>
<td>35.1</td>
<td>3.4</td>
</tr>
<tr>
<td>21S</td>
<td>7.2</td>
<td>116</td>
<td>417</td>
<td>11.8</td>
<td>22.7</td>
<td>3.0</td>
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<tr>
<td>21D</td>
<td>7.2</td>
<td>123</td>
<td>221</td>
<td>9.3</td>
<td>15.0</td>
<td>3.1</td>
</tr>
<tr>
<td>26S</td>
<td>7.8</td>
<td>57</td>
<td>255</td>
<td>8.3</td>
<td>4.3</td>
<td>1.5</td>
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<tr>
<td>26D</td>
<td>7.6</td>
<td>80</td>
<td>260</td>
<td>8.2</td>
<td>2.2</td>
<td>1.1</td>
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<td>6.9</td>
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<td>488</td>
<td>15.0</td>
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<td>6.9</td>
<td>149</td>
<td>334</td>
<td>9.6</td>
<td>13.3</td>
<td>3.3</td>
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</tbody>
</table>

S = shallow, 0-15 cm
D = deep, 15-30 cm
# Soil Test Results

## Trace Element Concentration

Sample collection date: April 9, 2009

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>Cu†</th>
<th>Mo†</th>
<th>Cd‡</th>
<th>Co†</th>
<th>Pb†</th>
<th>Zn†</th>
<th>Ni†</th>
<th>As†</th>
</tr>
</thead>
<tbody>
<tr>
<td>21 S</td>
<td>27</td>
<td>&lt;1</td>
<td>0.070</td>
<td>&lt;10</td>
<td>117</td>
<td>459</td>
<td>15</td>
<td>n.d.</td>
</tr>
<tr>
<td>21D</td>
<td>33</td>
<td>&lt;1</td>
<td>0.070</td>
<td>&lt;10</td>
<td>129</td>
<td>459</td>
<td>15</td>
<td>n.d.</td>
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<tr>
<td>9S</td>
<td>31</td>
<td>&lt;1</td>
<td>0.068</td>
<td>&lt;10</td>
<td>243</td>
<td>483</td>
<td>14</td>
<td>n.d.</td>
</tr>
<tr>
<td>9D</td>
<td>29</td>
<td>&lt;1</td>
<td>0.075</td>
<td>&lt;10</td>
<td>352</td>
<td>409</td>
<td>13</td>
<td>n.d.</td>
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<tr>
<td>26S</td>
<td>20</td>
<td>&lt;1</td>
<td>0.082</td>
<td>&lt;10</td>
<td>80</td>
<td>280</td>
<td>16</td>
<td>n.d.</td>
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<tr>
<td>26D</td>
<td>17</td>
<td>&lt;1</td>
<td>0.080</td>
<td>&lt;10</td>
<td>60</td>
<td>203</td>
<td>15</td>
<td>n.d.</td>
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<tr>
<td>39S</td>
<td>38</td>
<td>&lt;1</td>
<td>0.079</td>
<td>&lt;10</td>
<td>237</td>
<td>424</td>
<td>15</td>
<td>n.d.</td>
</tr>
<tr>
<td>39D</td>
<td>41</td>
<td>&lt;1</td>
<td>0.081</td>
<td>&lt;10</td>
<td>207</td>
<td>435</td>
<td>15</td>
<td>n.d.</td>
</tr>
</tbody>
</table>

S – Shallow, 0-15 cm
D – Deep, 15-30cm
n.d. = Non-Detectable by ICP-AES

†Analyses by ICP-AES
‡Analyses by GF-AAS
Soil Test Results

- No detectable chlordane
- Detectable levels of DDT (0.04 to 1.3 mg/kg) and DDE (0.03 and 0.04 mg/kg)
- DDE is a daughter/breakdown product of DDT
- DDT, an insecticide, was banned in the US in 1972, but is very persistent in soils (half-life of DDT ~15 yrs., DDE ~11 yrs.)
- Mildly to moderately elevated Pb levels
Potential Exposure Pathways

Direct exposure
Soil → Human

Indirect Exposure
Soil → Plant → Human
Ways to minimize Human Exposure to Pb in Soils

1. Wash hands (especially children)
2. Root vegetables should be washed and peeled before consumption
3. All other vegetables should be thoroughly washed prior to consumption
4. Apply soil amendments to reduce risk

Any other practices to minimize direct exposure to soil
Addition of soil amendments can reduce contaminant bioavailability

Bioavailability: the fraction of the chemical(s) of concern in soil that is accessible to an organism (human or plants) for absorption
## Trace elements in alfalfa

<table>
<thead>
<tr>
<th>pH</th>
<th>Cd</th>
<th>Mo</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.0</td>
<td>0.8</td>
<td>193</td>
</tr>
<tr>
<td>7.7</td>
<td>0.4</td>
<td>370</td>
</tr>
</tbody>
</table>

--- mg/kg ---

Source: Pierzynski, 1985
Recommendations

To minimize absorption of Pb (and DDT/DDE) by plants:

- Maintain soil pH levels above 6.5 to 7.0. - The soil pH at the WW site was about 7; therefore, no action was required

- Lead is also less available when soil P concentrations are high. Available P concentrations at the WW site soils were very high. So P addition was not necessary for this growing season

- Add organic matter to soil to reduce Pb availability to plants
Kansas City Test Plots

Summer 2009

Experimental Design:
Completely randomized block design (RCBD) in split-plot arrangement

Factor | Variables
--- | ---
Compost | yes, no
Plant type | tomato, sweet potato, Swiss chard
Test Plots
Test Plots
Total Pb Concentrations (determined by 4M HNO₃ digestion) in Soil
(prior to planting, June 2009)

<table>
<thead>
<tr>
<th>Main plot (Compost)</th>
<th>Subplot (Plant type)</th>
<th>Soil Total Pb (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>Swiss Chard</td>
<td>81.2 ± 4.2†</td>
</tr>
<tr>
<td></td>
<td>Sweet Potato</td>
<td>101.6 ± 16.3</td>
</tr>
<tr>
<td></td>
<td>Tomato</td>
<td>96.5 ± 10.8</td>
</tr>
<tr>
<td>No</td>
<td>Swiss Chard</td>
<td>95.3 ± 12.6</td>
</tr>
<tr>
<td></td>
<td>Sweet Potato</td>
<td>130.3 ± 10.3</td>
</tr>
<tr>
<td></td>
<td>Tomato</td>
<td>123.1 ± 21.1</td>
</tr>
</tbody>
</table>

† ±standard error of three field replicates
Test Plots

July 2009

September 2009
Plant uptake data

Analysis is on-going
Swiss Chard: preliminary data

<table>
<thead>
<tr>
<th>Compost</th>
<th>Cleaning Treatment</th>
<th>Pb concentration (µg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>Kitchen</td>
<td>288 ± 70†</td>
</tr>
<tr>
<td></td>
<td>Lab</td>
<td>306 ± 26</td>
</tr>
<tr>
<td>No</td>
<td>Kitchen</td>
<td>625 ± 199</td>
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<tr>
<td></td>
<td>Lab</td>
<td>495 ± 212</td>
</tr>
</tbody>
</table>

† ±standard error of three field replicates
Additional Benefits

Rundown house was painted, had new windows and a new porch installed

“They now have a garden instead on a blighted piece of property next door”

WW Gardeners
Plans for Next Year

• Move test plot at Kansas City site, larger test plots
• Add more project sites- different contaminants and/or contaminant mixtures
• Greenhouse experiments- to test effects of various amendments on contaminant uptake by plants
• Use PBET (Physiologically Based Extraction Test) to determine direct bioavailability of soil Pb to humans
Acknowledgments

Co-Investigators: Drs. Larry Erickson, Ted Carey, DeAnn Presley, Rhonda Janke, and Gary Pierzynski

Graduate Students: Ashley Rae, Phillip Defoe

Community and Partnering Organizations

Environmental Protection Agency