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Thesis Proposal

Johns Hopkins University

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Project Synopsis

For my thesis, I propose to review scientific literature related to "low intensity" bioremediation methods, as defined in this proposal. I will also conduct interviews with community organizations that have begun projects using low intensity bioremediation methods. The methods will be analyzed for their effectiveness as a form of remediation; their adherence to the definition of "low intensity"; and their potential to become a viable, small scale business.

Background

In response to concerns over economic uncertainty, climate change, energy depletion, and food safety issues, there has been a growing public interest in developing models of locally produced, sustainable and healthy food production. As more than fifty percent of the world's population is currently living in urban areas (PRB, 2007), many have begun the practice of having gardens and farms located within the geographical boundaries of cities. Such efforts may have the potential to provide city residents with a significant amount of their nutritional needs, and improve the overall quality of urban life for many.

Growing food in today's cities, however, has its challenges. Among them is the fact that many urban soils are heavily contaminated by industrial waste products produced in the past two centuries. Gardening in these soils is potentially dangerous, as plants grown in them can accumulate toxins that can be passed on to people when they are eaten. Also of concern is the risk of people, particularly children, coming into contact with or accidentally ingesting soil contaminants. (Harrison, 2009) Exposure to these pollutants over a lifetime can result in serious health problems for affected individuals.

Conventionally, and at great cost, contaminated soils are excavated and land filled. While this may be an appropriate action in highly contaminated environments, in many instances where lower levels of contamination are present, it is possible to address soil toxicity using a method called bioremediation. Bioremediation is the process of using the biological properties of naturally occurring organisms, primarily microorganisms, fungi,

and plants, to degrade, immobilize, or sequester environmental toxins. (Cookson, 1995) The main advantage of bioremediation is that it is considerably less expensive that conventional treatments, and can be performed “in-situ” with minimally disruptive techniques. (Cookson, 1995) In some circumstances, bioremediation methods can be utilized by persons without extensive scientific training.

In urban areas, there are many “brownfields” or properties that remain undeveloped due to existing or perceived contamination issues. It may be possible for community organizations to employ bioremediation techniques to remediate these properties and to make them usable for urban agriculture. I hypothesize that development of basic bioremediation techniques and subsequent citizen training is needed for the broad scale detoxification of soils and the development of localized urban-based food security.

Alongside of the interest in urban farming is a desire for the creation of “green jobs”. I further hypothesize that when sustainable practices are joined with economic activity, the rate at which they are implemented will greatly increase. There is great potential to develop small scale, urban- based industries that produce by-products that can be used for bioremediation and ecological regeneration. Some examples of these ecologically regenerative micro-industries include composting operations and edible mushroom cultivation. Both of these processes yield microbial and enzyme rich products that can be useful in degrading soil contaminants. An added benefit to both of these is that a large amount of the material inputs needed for each can be provided from waste sources. In the instance of compost remediation, it is possible for soil based metals to bind with the organic structure of the compost, and in doing so become biologically unavailable. (EPA, 1997)

Another possible coupling of industry and remediation is the practice of growing woody plants, such as willows, for biomass energy on lead contaminated soils. Known as phytoremediation, the willows would accumulate lead form the soil, and following incineration, the lead-containing ashes would be disposed of safely. There are also community organizations in the country today that have obtained contracts from

municipalities to engage in cleanup of lead contaminated properties using phytoremediation techniques. (Witters, 2007)

Methodology

A. Literature Review

I am proposing to conduct a survey of peer reviewed academic papers and studies of "low-intensity" bioremediation methods dealing with the top 12 inches of soil. The scope is narrowed to remediation methods that address this area of soil as it is of greatest concern to gardeners. For the purposes of this research, I will define that a method can be considered "low intensity" if it meets the following parameters of inclusion:

1. Non-invasive: The goal of a non-invasive procedure is to cause minimal disturbance and compaction to the existing soil and to its indigenous microbial population.
    a. Does not involve drilling wells either for groundwater monitoring, or the injection of chemicals or microbial cultures.
    b. Does not involve excavating any more than the top 12 inches of soil in any location.
2. Low cost: The total cost of the treatment of a 0.25 acre parcel does not exceed $10,000.
3. Low energy inputs:
    a. Minimal use of fossil fuel inputs; and/or
    b. Relies upon renewable, non-polluting energy sources including human, solar, biofuel, and wind power.
4. Not requiring specialized training:
    a. Designed to be simple enough to be utilized by people without extensive education in the fields of science and engineering.
    b. A training session running the course of a single weekend is sufficient to provide all necessary skills and knowledge in order to employ a low-intensity method.
5. Excludes the use of genetically modified organisms and nanotechnology.

In addition to the above parameters, a method would be excluded from the definition of "low intensity" if it relies upon the use of chemical oxidants, which at present are not available at affordable prices in sufficient quantities for the average citizen. Low intensity methods rely upon the metabolic processes of naturally occurring biological organisms in order to remediate contaminated soils. Also excluded are mechanically driven systems, such as bioventing, where large machinery is required to force air through soils. Acceptable uses of machinery include using air pumps for culturing microbes in compost tea, and the use of machines for turning or aerating compost piles.

Possible methods to be reviewed include: mycoremediation using *Pleurotus ostreatus* and mycorrhizal fungi, phytoremediation using phytoextraction and phytostabalization, vermiremediation, biochar, and compost and compost tea applications.

C. Evaluation

The methods used in the literature review will be analyzed on 3 levels:

1. Is the method an effective form of remediation? To what extent are toxins removed? (Ex. pre-contaminated levels, some reduction, EPA residential standards, etc.)

2. Does it meet the parameters of inclusion (detailed above) for a low intensity method of bioremediation?

3. Does the method offer the potential to become a viable small business (fewer than 10 employees)?

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Comment: As you move forward with the project you will have to think thru what parameters make a small business "viable."

D. Final Report

The final report will include descriptions of methods covered in literature review and a narrative of my evaluative findings. The final report will be reviewed by my project mentor, and then submitted to Johns Hopkins University.

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Timeline

a. 1-20 to 2-7 collect background documents
b. 2-8 to 3-8 analyze information
c. 3-9 to 4-6 compose results
d. 4-7 to 4-21 deliver draft for review
e. 4-21 to 5-7 complete final of report for submission to JHU

Project Advisors

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Cookson JT. Bioremediation Egineering : design and application / John T. Cookson, Jr. New York :: McGraw-Hill. 1995.

Harrison, Ellen, Murray McBride, and Hannah Shayler. Cornell Waste Management Institute. “Soil Contaminants and Best Practices for Healthy Gardens”. 2009. Accessed online: http://cwmi.css.cornell.edu/Soil_Contaminants.pdf

PRB – Population Reference Bureau "World Population Highlights: Key Findings from PRB's 2007 World Population Data Sheet." Accessed online: http://www.prb.org/Articles/2007/623Urbanization.aspx

United States Environmnetal Protection Agency. “Innovative Uses of Compost Bioremediation and Pollution Prevention”. 1997. Accessed online: http://www.epa.gov/osw/conse

Witters, Nele , Stijn Van Slycken, Ann Ruttens, Kristin Adriaensen, Erik Meers, Linda Meiresonne, Filip M. G. Tack, Theo Thewys, Erik Laes and Jaco Vangronsveld. “Short-Rotation Coppice of Willow for Phytoremediation of a Metal-Contaminated Agricultural Area: A Sustainability Assessment” Bioenergy ResearchVolume 2, Number 3, 144-152, Accessed online: http://www.springerlink.com/content/3566152627724541/rve/rrr/composting/pubs/bioremed.pdf