EVALUATING THE ABILITY OF *ALYSSUM MURALE* TO EXTRACT AGED NICKEL FROM NICKEL-ENRICHED ORGANIC SOILS

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1. Introduction

Port Colborne, Ontario, has an area of nearly 30km^2 that has been contaminated by emissions from a nickel (Ni) refinery that was in operation between 1918 and 1984. Emissions from the process of converting Ni-rich ores to marketable forms of Ni have left elevated Ni concentrations in the surrounding soil. These elevated Ni concentrations are causing phytotoxicity and are suspected of reducing crop yield in some agronomic species. Common remediation techniques (such as 'dig and dump') are not feasible or economically efficient because of the large area that has been contaminated. Phytoremediation would be a cost-effective and sustainable alternative, if its efficacy could be demonstrated on spatial and temporal scales.

Nickel hyperaccumulating plant species are able to accumulate at least 1000 mg kg^{-1} of Ni in their dry biomass without succumbing to toxicity. *Alyssum murale*, a hyperaccumulator of Ni that is native to Ni-rich serpentine soils from Mediterranean Europe, is a species of interest for phytoremediation. Extensive research has been conducted regarding the ability of *A. murale* to extract Ni from Ni-enriched soils (Chaney et al., 1998, 2000, 2005; Li et al., 2003; McNear et al., 2007; Fellet et al., 2009; Centofanti et al., 2012). Research shows that *A. murale* is able to extract Ni from soils with elevated concentrations of Ni without showing signs of toxicity; however the spatial and temporal capacity of this species as a perennial crop to measurably reduce the concentration of Ni in soils has not been demonstrated.

2. Materials and methods

To determine the capability of perennial cropping with *A. murale* as a phytoremediation technology, a mathematical model of soil → plant Ni mass transfer was created. The use of mathematical models to simulate environmental scenarios is efficient as different inputs and outputs can be evaluated without experimenting with the environment. Human rationality, which may promote an error and/or bias, is also eliminated (Canales-Pastrana et al., 2013).

STELLA® Professional, a simulation software used to express changes in a system over time, incorporates specific parameters and process rates to create an interactive output. In 2013, Canales-Pastrana et al. used STELLA® Professional to model a system that expressed the rate at which plants are able to volatilize soil mercury under given

circumstances. The model created was able to use specific values to demonstrate the overall extraction capability of the plant. With the use of a STELLA® Professional, a graphical representation of the extraction capability of *A. murale* and a hypothetical timeline for reduction in soil Ni concentration was created. A soil → plant Ni mass transfer model was designed using various assumed values to determine the time required for sequential cropping of *A. murale* to remediate the contaminated soils to (1) an initial target level of 1000 mg kg^{-1} (Dan et al., 2008), and (2) the Ministry of the Environment and Climate Change (MOECC) component value for plants of 100 mg kg^{-1} (Ministry of the Environment, 2011). Variables used in the model include initial soil Ni concentration, an extraction rate, an initial *A. murale* Ni concentration value and a cropping factor that accounts for 100% of A. murale being cropped initially at 1 year, then at 1 year intervals.

3. Preliminary results and discussion

Various scenarios can be created with the use of STELLA® Professional. Preliminary models incorporate values from previous work (Li et al., 2003), and pot study data collected in 2015. Figure 1 shows a base STELLA® Professional model that is used to input values to create a graphical output. Using various assumed values for the rate control steps of STELLA® Professional, preliminary estimates of half-life of soil Ni range between 11 years and 250 years.

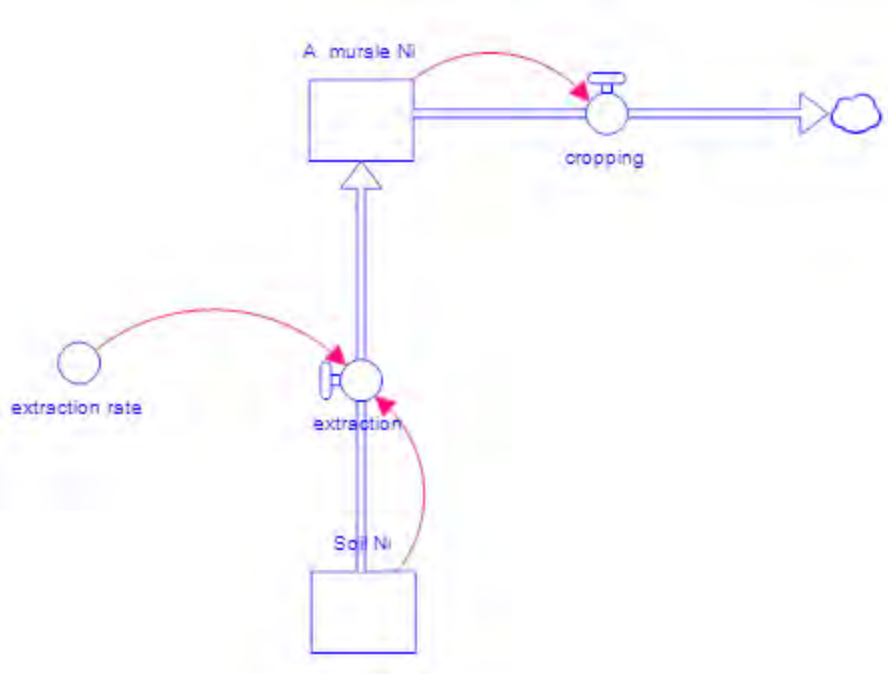

Figure 1: Preliminary soil→ plant mass transfer model created using STELLA® Professional

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