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Introduction

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Abstract

Land management is an important sustainability challenge in many locations because of contamination and/or degradation. There are many aspects related to reducing risk associated with contaminants in soil and improving soil quality. The science and engineering of phytotechnologies with biomass production have been advanced in many countries with much of the research being published after 1985. In most phytotechnology applications at contaminated sites, improving soil quality is a priority, and productive use of the land is one of the goals. Remediation of contaminated soil has great value for society and being able to produce a biomass product to improve the economics is very beneficial in countries where resources to address environmental challenges are limited. Miscanthus is a very valuable biomass product and an effective plant for many applications because of its properties. Since partial funding has been provided by NATO, an effort has been made to address topics that are important to NATO countries in this work.

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1.1 Soil Quality

Soil quality is a high priority because of food and other useful products that can be produced through agriculture and forestry. Each plot of land

has features that can be nurtured in order to improve soil quality and crop productivity. Stewardship of soil and the restoration of contaminated sites are important in many countries.

The soil scientist characterizes soil in terms of physical properties such as particle size distribution, chemical properties such as pH and percent nitrogen (N), and biological properties such as number of microorganisms per gram of soil. Soil quality depends on having a desirable amount of many different substances in soil.

1.1.1 Soil Contamination

This book has a focus on phytotechnologies for contaminated sites. The NATO funding for multiyear research project of the Science for Peace and Security Program (SPS MYP) #G4687 entitled Phytotechnology for Cleaning Contaminated Military Sites has a goal to improve the economics of phytoremediation by producing plant biomass that has economic value. There are many locations in the world which are contaminated with substances in the soil that reduce the value of the products that are harvested because yield is reduced or the products are of lower quality. In some cases, health and safety issues may prevent the land from being used for the production of food and feed crops. Risk reduction is one of the important issues in many locations where contaminants are present.

There is value in approaching the topics in this book using a sustainability approach in which social value, environmental quality, and economic benefits are all considered to be important. Each site with contamination has the potential to be improved such that it can be used productively for the benefit of society. Many investigators have reported on their efforts to develop methods and approaches that advance the science and engineering associated with phytotechnologies. One of the goals of this book is to collect and write about some of these developments.

The research site at Fort Riley, Kansas, where *Miscanthus* has been established has lead in soil. Because of its use for military purposes, lead in soil is a contaminant of concern at a number of military sites. At a research site at Dolyzna, Ukraine, there are other inorganic contaminants in the soil.

Petroleum contaminated soil is common on military lands and at sites where vehicles are refueled. Petroleum refineries often have one or more contaminated areas. Pipeline spills are commonly found in many countries, and the spill may be due to military operations designed to disrupt supplies. Pesticides are often contaminants of concern on military lands and at other locations.

There are many locations where mining operations have ended with land that needs to be restored to better quality. Minerals, coal, lime, and other products are mined to obtain useful raw materials, but there are other solid residues that remain at the site. These mine tailings are often an important challenge in efforts to improve soil quality.

Salt is a contaminant of concern when it is present in soil at a high concentration. High salt concentrations may be from oil and gas production or irrigation water that has too much salt.

Coal ash is a residue from coal combustion for electricity or to fire a boiler at an industrial site. There are also residues from other industrial processes such as steel mills.

1.1.2 Types of Contaminants

There are two important types of contaminants in soil: inorganic and organic substances. Organic contaminants such as gasoline can be biodegraded by biological processes to carbon dioxide and water. Inorganic contaminants such as lead, other trace elements such as zinc, and salts do not biodegrade. They are managed by other processes such as phytostabilization. Both types of contaminants are important and are considered in this book.

1.2 Phytotechnology with Biomass Production

One of the core topics in this book is how to restore soils that are contaminated. There are many ways to make use of the beneficial effects of vegetation in contaminated soil. The concept of using plants to both improve soil quality and produce a product that has commercial value has been investigated by a number of research teams and used in practice (Alexopoulou 2018; McCutcheon and Schnoor 2003; Nsanganwimana et al. 2014; Pidlisnyuk et al. 2014). This is one of the core topics of this book, which will be described further in other chapters. While the NATO project research has been with *Miscanthus*, there are many other plants that have the potential to be used commercially to both improve soil quality and harvest a product that can be marketed and sold.

1.3 Miscanthus

The focus of this book includes growing *Miscanthus* at contaminated sites in order to have a product to harvest and sell. *Miscanthus* has been the subject of considerable research because of the large amount of biomass that can be produced (Alexopoulou 2018; Lewandowski et al. 2000; Jones 2020). *Miscanthus* crops may exceed 3 m in height and annual yields may be more than 25 Mg ha⁻¹ (Jones 2020). *Miscanthus* genetics and the development of hybrids that have desirable features are important. Establishing *Miscanthus*

plants and other vegetation in contaminated soil is the subject of a separate chapter because of its importance. Soil fauna have great value in improving soil quality when *Miscanthus* is grown in contaminated soil.

The markets for *Miscanthus* include its use as a biofuel and as a bio-based product in buildings, paper industry, vehicles, or other applications. The economics associated with the marketing of *Miscanthus* vary with location and with the efforts in various countries to have policies to reduce greenhouse gas emissions.

1.4 Case Studies

This book includes several recent examples of efforts to produce *Miscanthus* while also improving soil quality at field sites in several countries. At each field site, there are applications of the science and technology described in the various chapters. The details of many of the case studies are presented in other publications which are included in the references associated with each case study.

References

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