Austin Environmental Sciences

Open Access

Austin Publishing Group

Editorial

Bioremediation of Industrial and Municipal Waste Ponds Contaminated with Polychlorinated Biphenyls (PCBs)

Lowman JS[1,2] **and Mei C**[1,2,3]***

[1]The Center for Sustainable and Renewable Resources, Institute for Advanced Learning and Research, USA

[2]Department of Horticulture, Institute for Advanced Learning and Research, USA

[3]Department of Forest Resources and Environmental Conservation, Virginia Polytechnic and State University, USA

***Corresponding author:** Chuansheng Mei, The Center for Sustainable and Renewable Resources, Institute for Advanced Learning and Research, USA

Received: November 11, 2016; **Accepted:** November 20, 2016; **Published:** November 21, 2016

Introduction

In 2007, the U.S. Department of Health and Human Services' Agency for Toxic Substances and Disease Registry listed Polychlorinated Biphenyls (PCBs) as the number 5 toxic substance in the US. Prior to the late 1970s, PCBs were commonly used in many ways in industrial settings including, but not limited to, electrical transformer cooling oil, hydraulic oils, lubricants, cutting oils, and printer's ink. In many instances, these fluids were disposed of in floor and sink drains, eventually finding their way to municipal and industrial sewage processing facilities. These practices were not illegal and commonly accepted prior to their ban in the late 1970s. Almost forty years later, these persistent compounds still remain in the systems where they were disposed. The amount and commonality of this type of PCB contamination has not been estimated, but is likely very common given the amount of industrial manufacturing that took place in the US from 1930 to 1977. While PCBs are persistent and relatively stable in the environment, they are also organic molecules and are subject to anaerobic dechlorination and aerobic metabolism by various bacteria. In this editorial communication, we focus on Waste Water Treatment Ponds (WWTP) and strategies for bioremediation in different situations, highlighting our efforts to remediate PCBs in a WWTP at a small town in Central Virginia by utilizing a combination of switch grass and bacteria.

Methods for Remediation

Several methods could be used to remediate PCBs in contaminated soil or sludge. Traditional remediation methods of PCB-contaminated soil or sludge use physical and/or chemical treatments including dig and haul, solvent extraction, thermal alkaline dechlorination, incineration, or land filling [1]. The methods are very costly and not environmentally friendly. In cases such as dig and haul and land filling, the risk may stay with the locality or industry where the contamination originated. Recently, bioremediation has gained more attention because it uses living organisms and systems including plants and microorganisms to break down these toxic compounds. Generally, bioremediation includes phytoremediation, microbial remediation, and/or combination of plants and microbes. Phytoremediation uses living plants to absorb, accumulate, and/or degrade and remove contaminated toxic compounds from the soil, and poplar trees are perhaps the most used plants to remediate organic toxic compounds in the US. However, plants can suffer serious damage, showing slow growth or abnormal development, often leading to slow removal and incomplete degradation. They may also simply uptake and augment in plants because they lack the catabolic enzymes needed to degrade organic pollutants [2]. Unlike phytoremediation, microbial remediation uses bacteria or fungi to degrade and remove soil contaminants and pollutants via specific enzymes which can break down these toxic compounds. For example, *Burkholderiaxenovorans* LB400, formerly known as *B. fungorumis*, a potent PCB-degrading bacterium [3] and *Pandoraeapnomenusa* B-356 [4], have Biphenyl dioxygenase(bph) genes which code for enzymes that can break down PCBs. The combination of plants and bacteria is a promising way to remediate contaminated soil and sludge [5] in industrial and municipal waste water treatment facilities.

Altavista is an incorporated town in south-western Campbell County, Virginia and has been home to a vibrant industrial base since the beginning of the 1900s. For many years prior to the late 1970s, PCBs were unknowingly deposited by these industries into their overflow pond adjacent to the waste water treatment plant. After initial site testing and the determination through monitoring wells that the contaminants were not entering the ground water, the town began exploring options to clean up the facility. When faced with unfeasible dig and haul estimates of over 10 million dollars, this small town with less than 3500 people began to explore lower cost and more environmentally friendly options. Over the last several years, the town has worked with universities and research institutions to try to find feasible and low cost options to rid the pond of PCBs. In order to get public attention on their PCB challenge as well as exchange results with a broader research community, the Institute for Advanced Learning and Research (IALR), in collaboration with the United States Environmental Protection Agency (EPA), held a workshop titled "Altavista's 6-acre Petri Dish: Testing Sustainable Solutions for PCB Contaminated Sediments" in Danville, Virginia on June 17-18, 2015. This workshop highlighted lab and field work as well as research resulting from three years of in situ PCB biodegradation trials in the WWTP in the Town of Altavista. Based on our previous work on the bio energy crop switch grass and beneficial bacterial endophytes, we are conducting experiments on site which combine switch grass, bacterial endophytes, and PCB degrading bacteria for PCB remediation.

Future Perspectives and Challenges

Bioremediation with a combination of plants and microbesis a promising approach for remediating soil and sludge polluted with organic toxic compounds because it is sustainable, cost effective and

Citation: Lowman JS and Mei C. Bioremediation of Industrial and Municipal Waste Ponds Contaminated with Polychlorinated Biphenyls (PCBs). Austin Environ Sci. 2016; 1(3): 1013.

environmentally friendly. Microbes benefit plants since they can promote plant growth by increasing nutrient uptake and enhancing stress tolerance. Plants used for remediation should grow fast, tolerate abiotic stresses, and require little inputs. Bio energy crops such as switch grass and poplar trees are fast growing plants, have high biomass, require low inputs and can grow in poor soil and contaminated sites. Furthermore, the root systems of switch grass and poplar trees are immense, providing extensive surface area to support PCB degrading bacteria and to penetrate soils completely. A solution that has not been applied to our knowledge is genetic modifications that could be introduced to such microbes responsible for remediation as microbes are much more easily engineered compared to plants [6]. Many of the same bacterial genera responsible for PCB degradation, such as *Burkholderia*, are often able to promote plant growth [7]. Because of this, scientists can engineer beneficial bacteria to include genes for degradation of toxic compounds and speed up remediation. Of particular benefit are bacterial endophytes, which live inside plants [8] and are closely associated with plants in a mutually beneficial relationship. Host plants provide nutrients to bacteria, and in return bacteria help plant tolerance to toxic compounds by degrading these compounds. Transgenic bacterial endophytes would not only benefit plants by promoting plant growth and enhancing stress tolerance, but also would have the ability to break down toxic compounds into less toxic or nontoxic products, which plants may use as nutrients. One possible problem that needs further investigation, however, is that the relatively stable PCB molecules may be degraded into less stable and more or less toxic compounds, which may be more volatile. Furthermore, we need to know if any PCBs remain and accumulate in plants.

References

1. Campanella BF, Bock C, Schröder P. Phytoremediation to increase the degradation of PCBs and PCDD/Fs: Potential and limitations. Environmental Science and Pollution Research. 2002; 9: 73-85.
2. Aken BV, Correa PA, Schnoor JL. Phytoremediation of polychlorinated biphenyls: New trends and promises. Environ Sci Technol. 2010; 44: 2767-2776.
3. Chain P, Denef V, Knstantinidis K, Vergez LM, Agullo´ L, Reyes VL, et al. Burkholderiaxenovorans LB400 harbors a multi-replicon, 9.73-Mbp genome shaped for versatility. Proc Natl Acad Sci USA. 2006; 103: 15280-15287.
4. Gómez-Gil L, Kumar P, Barriault D, Bolin JT, Sylvestre M, Eltis LD. Characterization of biphenyl dioxygenase of PandoraeapnomenusaB-356 as a potent polychlorinated biphenyl-degrading enzyme. J Bacteriol. 2007; 189: 5705-5715.
5. Arslan M, Imran A, Khan QM, Afzal M. Plant–bacteria partnerships for the remediation of persistent organic pollutants. Environ Sci Pollut Res. 2015; 1-5.
6. Afzal M, Khan QM, Sessitsch A. Endophytic bacteria: prospects and applications for the phytoremediation of organic pollutants. Chemosphere. 2014; 117: 232-242.
7. Kim S, Lowman S, Hou G, Nowak J, Flinn B, Mei C. Growth promotion and colonization of switchgrass (Panicumvirgatum) cv. Alamo by bacterial endophyte Burkholderiaphytofirmans strain PsJN. BiotechnolBiofuels. 2012; 5: 37.
8. Mei C, Flinn BS. The use of beneficial microbial endophytes for plant biomass and stress tolerance improvement. Recent Patents Biotechnol. 2010; 4: 81-95.

Austin Environ Sci - Volume 1 Issue 3 - 2016
Submit your Manuscript | www.austinpublishinggroup.com

Citation: Lowman JS and Mei C. Bioremediation of Industrial and Municipal Waste Ponds Contaminated with Polychlorinated Biphenyls (PCBs). Austin Environ Sci. 2016; 1(3): 1013.