Microbial Bioremediation in Omics era: Opportunities and Challenges

Jincai Ma1 and Guangshu Zhai2*

1Biosciences and Biotechnology Division, Lawrence Livermore National Laboratory, Livermore, CA 94550, USA
2Department of Civil and Environmental Engineering and IIHR Hydroscience and Engineering, The University of Iowa, Iowa City, IA 52242, USA

Introduction

Bioremediation is a sustainable solution to clean up the organic pollutants from the contaminated sites. Both plants and microbes play leading roles in bioremediation processes. Compared to phytoremediation, microbial bioremediation is paid more attention and has wide applications since microorganisms are ubiquitous in the environment and they are able to function under various conditions, especially at really extreme environmental conditions where plants cannot survive.

Previous microbial bioremediation research focused on chemical kinetics, intermediate products and final product identification and quantification of organic pollutants, while studies on the molecular mechanisms behind the contaminant transformation processes received less attention largely due to technical difficulties. Although using traditional molecular techniques, some functional genes involved in the microbial degradation of a specific contaminant have been discovered. The advancement in modern molecular biology, system biology, and availability of whole genome sequence data, fosters new techniques including genomics, transcriptomics, proteomics, and metabolomics, which might potentially be applied in bioremediation of organic chemicals in the environment. For example, genomics provides the information on the whole genome of an organism where specific genes can be found to degrade the specific organic pollutants and metabolomics studies the metabolites of organic contaminants formed during the microbial reactions. From genomics to metabolomics, we are able to achieve a complete understanding of the microbial processes and to better direct bioremediation in field application.

Recently, more environmental scientists have tried to apply those state-of-the-art technologies in environmental sciences though all of those techniques were initially applied for biomedical sciences. Definitely, those techniques pave a way for environmental microbiologists toward a better understanding of the molecular mechanisms involved in microbial bioremediation processes, which in turn will improve the effectiveness of microbial bioremediation and help to design a more technical sound strategy to clean up the contaminated sites.

It might be right to say that microbial bioremediation has entered into an Omics era. However, it should be noted that the environmental system is more complex than well controlled laboratory ones based on which the original Omics techniques are developed. In the real environment, the diversity and abundance of microbes and associated environmental factors subject a lot of spatial and temporal variations. Therefore, when focuses on environmental samples, Omics techniques mentioned have been termed as meta-Omics. In the Omics era, environmental scientists have plenty of opportunities, and at the same time also face many challenges. The major opportunity exists that environmental microbiologists have an option to deeply investigate the biological mechanisms involved in bioremediation processes. Indeed, the Omics techniques has been applied to investigate contaminants degradation [1-3], more researchers have started to utilize those tools together with traditional strategies to elucidate the decontamination mechanisms, which will result in achievements of a tremendous amount of scientific finding regarding bioremediation processes. However, there is still a long way to achieve a mature Omics era. Currently the major challenges are as the following:

1) Availability of computation resources. More and more data have been and are being generated. Data analysis might be a major bottle neck for environmental bioremediation processes.

2) Lack of reference database, especially the reference chemicals for metabolomics, where some metabolites with unknown structure might be produces.

3) Complicated environmental conditions. There might be different bioremediation mechanisms for the same microorganism to degrade the same organic compound under various environmental conditions.

In the Omics era, the future research in microbial bioremediation might focus on

1) Data mining of the current data to provide more insights into the mechanisms of bioremediation.

2) Numerical modeling and numerical simulation, which requires development of novel algorithms.

3) Standardized the protocols for data collection, analysis, storage, and transmission.

4) Identification of novel biomarkers. Those markers might be used for diagnostic of bioremediation operations. The biomarkers could be functional genes, important enzymes, and indicator metabolites formed during the bioremediation reactions.

5) Integration of data generated by different Omics techniques. By integrating functional genomics, proteomics, transcriptomics, and metabolomic data, we might be able to provide a more complete picture of a microbial bioremediation system and achieve a detailed understanding of the physiological state of microbes used for bioremediation purposes.

References


*Corresponding author: Guangshu Zhai, Department of Civil and Environmental Engineering and IIHR Hydroscience and Engineering, The University of Iowa, Iowa City, IA, 52242, USA, Tel: +1 319-335-5866; E-mail: zhai-guangshu@uiowa.edu

Received July 25, 2012; Accepted July 26, 2012; Published July 30, 2012

Citation: Ma J, Zhai G (2012) Microbial Bioremediation in Omics era: Opportunities and Challenges. J Bioremed Biodeg 3:e120. doi:10.4172/2155-6199.1000e120

Copyright © 2012 Ma J, et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.