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Heavy metal pollution in Tianjin, China—its bioavailability prediction and mitigation practice

Hongwen SUN, Ting WANG, Yanfeng ZHANG, Chunxiao JIANG, and Jing WANG

MOE Key Laboratory of Pollution Processes and Environmental Criteria, College of Environmental Science and Engineering, Nankai University, Tianjin, 300071 China (sunhongwen@nankai.edu.cn/86-22-23509241)

Irrigation of sewage water has been applied for agriculture production in Tianjin for over 50 years, for Tianjin is a city lacking water resource. Based on the result of an extensive investigation on heavy metals in the farmland of Tianjin in 2005, 21 samples (including soil and lettuce) were collected from most the polluted areas along the three sewage rivers. Nine of the 21 soil samples exceeded the National Soil Quality Standard for cadmium (0.6 mg/kg) and 7 exceeded the standard for mercury (1.0 mg/kg). However, the heavy metal contents in lettuce did not correlate the heavy metal concentrations in soil. The bioavailability changed with soil properties. The part extracted by diethylene-triaminepentaacetic acid (DTPA) and another mixed extraction solvent, M3, were used to predict the bioavailability of heavy metals. The solvent extraction gave good prediction on Cd absorbance in lettuce, with correlative coefficient larger than 0.9. However, it failed for Hg. This may be because Hg is relatively volatile, and the absorption patterns are complex for Hg.

To set up a mitigation method for heavy metal pollution in farm land, friendly to agricultural production, in-situ fixing strategy was adopted. Bacillus subtilis and Candida tropicalis were induced by ultraviolet (UV) radiation and HNO2 treatment to get mutated strains that can tolerate and accumulate higher level of cadmium. A strain of B38 from B. subtilis showed the highest Cd tolerance, and was used for further experiment. Though B38 could accumulate Cd from water solution, but it did not fix Cd in soil. This is due to that the amended microorganisms could not propagate well in the polluted soil. Novogro, which is produced from the waste of an enzyme factory, was selected out from several materials to amend together with B38. After the co-amendment of Novogro and B38, the DTPA extractable Cd decreased by 72%, and B38 could propagate efficiently as indicated by DGGE test. Applying conditions, such as amendment amount of Novogro and B38, pH, water content, were optimized.

Pot experiments showed that this combined technology could reduce the absorption of Cd for several vegetable species, and promote their growth. Finally, the technology was successfully applied to vegetable production in field, and the heavy metal absorption (mainly Cd and Hg) was reduced by 14-66%. This study provides an environment friendly remediation technology with low cost.