Occurrence and correlations of many trace metals in sludge from over 40 sewage treatment plants in China

DAVE TA FU KUO[1,2,*], QIHANG WU[3,5], MINGJUN DENG[3,4], XIAODONG HU[3,4], ZHINENG LIU[3,4], HAOZHI ZHANG[3,4]

[1]Department of Architecture and Civil Engineering, City University of Hong Kong, Hong Kong, China; (*correspondence: dave.kuo@cityu.edu.hk)

[2]City University of Hong Kong, Shenzhen Research Institute, Shenzhen 518057, China.

[3]Key Laboratory of Water Quality Safety and Protection in Pearl River Delta, Guangzhou University, Guangzhou 510006, China; (wuqihang@gzhu.edu.cn, mingjun0426@163.com, hxd60@126.com, lzn_2015@126.com, zhanghaozhi2008@163.com)

4 School of Civil Engineering, Guangzhou University, Guangzhou 510006, China.

5 Collaborative Innovation Center of Water Quality Safety and Protection in Pearl River Delta, Guangzhou University, Guangzhou 510006, China.

Underlying the comfort and convenience of modern life is the use of diverse trace metals in various industrial and consumer products. This study investigated their fate in wastewater treatment systems. Sludge samples from 44 industrial and municipal wastewater facilities in China were analyzed for the occurrence and distribution of 39 trace metals. The facilities were located in the province of Shanxi, a coal and heavy industry hinterland, and Guangdong, a modernized and manufacturing-intensive coastal province. Samples were digested and analyzed for trace metals using ICP-AES and ICP-MS. The total concentration of the 39 trace metals (i.e., $\Sigma Metal_{39}$) ranged from 1900 to 22000 mg/kg with Ti, Zn, Ba, and Mn constituting approximately ¾ of $\Sigma Metal_{39}$. Concentration of 11 of the 12 heavy metals currently regulated in China ranged from 470 to 19000 mg/kg in the sludge samples. Zn was the dominant element and on average accounted for half of $\Sigma Metal_{reg\text{-}11}$. Cu, Cd, and Zn levels exceeded soil regulatory standards in 86%, 93%, and 100% of the samples, respectively. A number of moderate to strong correlations were found between concentrations of selected trace metals. They may reflect similar environmental behavior among elements of the same periodic groups or point to their common applications or sources of release. Overall, these correlations may support quick assessment on total sludge metals content based on selected indicator elements. This study can serve as a benchmark for environmental inventory of sludge trace elements in China.