X-ray absorption spectroscopy to elucidate the behavior of heavy metal in organic waste agricultural recycling

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ABSTRACT

In the past century, waste production has risen tenfold, and by 2025 it will double again to reach 6 million tonnes per day[1]. Solutions have then to be found to this waste problem. Organic waste (e.g. pig slurry, sewage sludge etc.) represent a significant part of the world waste production and can be valorized following two routes. The first one is agricultural recycling. Organic wastes (OW) have fertilizing properties and can be used as an alternative to chemical fertilizers[2]. The second one is an energetic valorization. OW can be digested to produce biogas used to generate electricity and heat. Besides, this digestion produces a by-product than can also be recycled in agriculture[3].

However, OW can have high pollutant concentration among which heavy metal (HM) is particularly concerning. Indeed, soils that have been amended with OW can present HM accumulation at their surface layers[4]. This accumulation could induce phytotoxicity and groundwater quality degradation. Consequently, the fate of HM in the cultivated soil system after OW amendment is a key issue, and it can better be predict by determining their speciation in the OW.

Studies that investigate heavy metal speciation in OW with X-ray absorption spectroscopy (XAS) are presented. In the first study, pig slurry spreading on a tropical soil is used as an example (agricultural recycling valorization). Pig slurry present high concentration of Cu and Zn. Field experiment showed Cu and Zn accumulation in soil at different layers[4]. XAS permitted to elucidate the Cu and Zn speciation in pig slurry[5] and explain their behavior on the field. The second study deals with anaerobic digestion of OW (energetic valorization). The anaerobic digestion of the studied OW permitted the production of methane, but increased the Cu and Zn concentration in the by-product. XAS was used to compare the Cu and Zn speciation in the OW (before digestion) and in the by-product (after digestion). Results shows that the anaerobic digestion tends to modify the Cu and Zn speciation.

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