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猪、奶牛粪厌氧发酵中**Pb**的形态转化及其分布特征

Distribution of Pb and its chemical fractions in liquid and solid phases of digested pig and dairy slurries

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中文摘要:

畜禽粪便经厌氧发酵后其中的铅（Pb）仍然保留在沼液和沼渣中，阐明此发酵过程中Pb的形态转化对沼液和沼渣的后续处理有重要的参考意义。该研究以猪粪和奶牛粪为发酵原料，在中温（37℃±2℃）条件下，采用连续搅拌反应器进行了130 d中试试验，分析了Pb在固相和液相中的分配及其形态转化。研究结果发现：1）与进料相比，猪粪沼液和奶牛粪沼液中总Pb量降低了约70%和19%；2）猪粪沼液和奶牛粪沼液中Pb在液相中的比例为29%和17%，较发酵前降低约17%和58%；3）厌氧发酵后，猪粪沼液中各形态Pb所占比例的大小顺序为：残渣态（35%）>酸溶态/可交换态（34%）>可还原态（24%）>可氧化态（8%）；奶牛粪沼液中为：可还原态（33%）>酸溶态/可交换态（27%）>残渣态（26%）>可氧化态（15%）；4）厌氧发酵后，猪粪沼渣中残渣态和酸溶态/可交换态Pb的比例都极显著增加，奶牛粪沼渣中可氧化态Pb的比例极显著增加。猪粪和奶牛粪厌氧发酵后，适合通过沉淀池或氧化塘削减沼液中的Pb含量；但沼渣中Pb的浓度较大且化学形态发生显著变化，建议还田前进行重金属钝化处理。

英文摘要:

Abstract: Anaerobic digestion treatment effectively degrades the organic matter and causes obvious variations in physical and chemical properties of digested slurries, such as water content, pH, oxidation reduction potential and microbial activities. These changes may influence the chemical fraction of Pb, which is a critical factor in predicting its toxicity, environmental mobility, bioavailability and optimum removal methods. The speciation and phytotoxic effects of lead from sewage sludge and composted manure have been widely studied. There has been no study about the transfer and distribution of Pb during anaerobic digestion of manure slurries. The aim of the present work was to analyze the distribution of Pb in both liquid and solid phase after anaerobic digestion of pig slurries and dairy slurries, and their chemical speciation in solid fraction of digested residuals. The continuous stirred tank reactor (CSTR) at condition of medium temperature [(37 ± 2)℃] was operated for 130 d. Lead in liquid and solid phases of raw materials and digested slurries was analyzed by first passing through a 0.45 μm filter paper. The chemical fractions in digested slurry solids were extracted by BCR method. Results showed that total amount of Pb was decreased 70% and 19% in digested pig slurries (DPS) and dairy slurries (DDS), respectively, , compared with raw slurries. The percentages of Pb in liquid fractions of DPS and DDS were 29% and 17%, which decreased by 17% and 58%. The decrease of Pb in DDS was significantly lower than that in DPS. One reason is that 90% of solids in DDS were discharged during the anaerobic digestion. Another reason is that Pb in digested slurries mainly exists as the solid form. Thus the amount of Pb left in the reactor for dairy manure digestion was significantly lower than that for pig manure digest. Due to the high removal efficiency, easy operation and low treatment cost of heavy metals in solid phase, transformation of liquid phase of heavy metals to the solid phase is essential for the post-treatment of heavy metals in digested slurries. As BCR scheme described, there are three mobile fractions of heavy metals (Table 3): the fraction that presented in ionic form, bound to carbonates and the exchangeable (F1), the fration that is susceptible to changes in ionic strength and pH; bound to amorphous Fe and Mn oxides and hydroxides (F2), and he fraction that is unstable in reducing conditions; bound to organic matter and sulfides (F3), which may be decomposed under oxidizing conditions and result in a release of the metals into the soil solution. The residual fraction (F4), left after the three steps is the most stable fraction and has less bioavailability. The chemical fractionations of Pb in residual solids were significantly changed. The percentage of fractionated Pb in digested pig slurries solid declined with the order of F4 (35%) > F1 (34%) > F2 (24%) > F3 (8%); while that in digested dairy slurries solid was F2 (33%) > F1 (27%) > F4 (26%) > F3 (15%). After anaerobic digestion, lead in F4 and F1 fractions significantly increased in residual solid digested with pig slurries; while lead in F3 fraction significantly increased in dairy slurries. However, the actually bioavailability of Pb after anaerobic digestion of pig and dairy manures should be studies by toxic test further. The sedimentation ponds or oxidation ponds were more efficient to cripple the Pb in DPS and DDS. However, the concentration of Pb in digested solids and its available fractions enhanced, which would be easier to be absorbed by plants. The passivants were recommended to add to the solid residues of digested animal slurries before farmland application.

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