

THE FATE OF HEAVY METALS IN ANAEROBIC DIGESTION PROCESS

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Introduction

As a direct consequence of environmental legislation (e.g. EU Nitrate Directive 91/676/EEC), farmers in regions with intensive livestock production need to find alternative ways to deal with their manure surplus. Increasingly, anaerobic co-digestion (AD) plays an important role in processing animal manure in such regions. This results in biogas as a renewable energy source and digestate as a nutrient rich fermentation residue. When digestate is applied to arable land as a bio-fertilizer, most of the micronutrients are fully utilized, as they are essential for plant growth. However some trace elements, such as Cu and Zn, have elevated concentrations in digestate, due to their addition to livestock feed as metabolic micronutrient. As such application of digestate could lead to Cu and Zn accumulation in agricultural soils and a permanent threat for humans by entering the food chain. Currently, digestate is being considered as potential candidate for End-of-Waste status. Accordingly, the concentration level of Cu and Zn in digestate must remain between the legal limits of 100-200 mg/kg dry matter and 400-600 mg/kg dry matter, respectively (European Commission, 2008). In practice, however, the elevated Cu and Zn levels in pig slurry as a feedstock for anaerobic digestion, pose a risk to exceed the currently proposed End-of-waste criteria. The aim of this study is to simulate concentrations in digestate for essential elements like Cu and Zn, based on their loading in natural products such as manure.

Methods

The basic principle for the simulation model is that up-concentration of heavy metals in digestate can be predicted based on biogas potential (i.e. mass reduction) and initial concentrations in feedstock. As a result, four different approaches of simulation model (M1 - Biogas Yield Approach; M2 – Biodegradation Factor Approach; M3 - Dry Matter Approach; M4 - Power Generation Approach) were proposed and validated with input data received from physicochemical and biogas batch test analyses of digestate from co-digestion (BP(A)) and mono-digestion (BP(B)) processing units. Sampling at biogas plants (BP) has taken place at 2 sampling moments, S1 and S2, with one month difference in between.

Results

The simulation models calculated approximate values of mass reduction factor reflecting the concentration of Cu and Zn in digestate as compared to results obtained from physicochemical and biogas batch test analysis. The difference between these concentrations gives an up-concentration factor which indicates how many times heavy metal concentration in digestate is higher as compare to input fed to digester. The compatibility factor between simulation models and laboratory data ranged in following order: $M3 > M2 > M1 > M4$ (Figure 1).

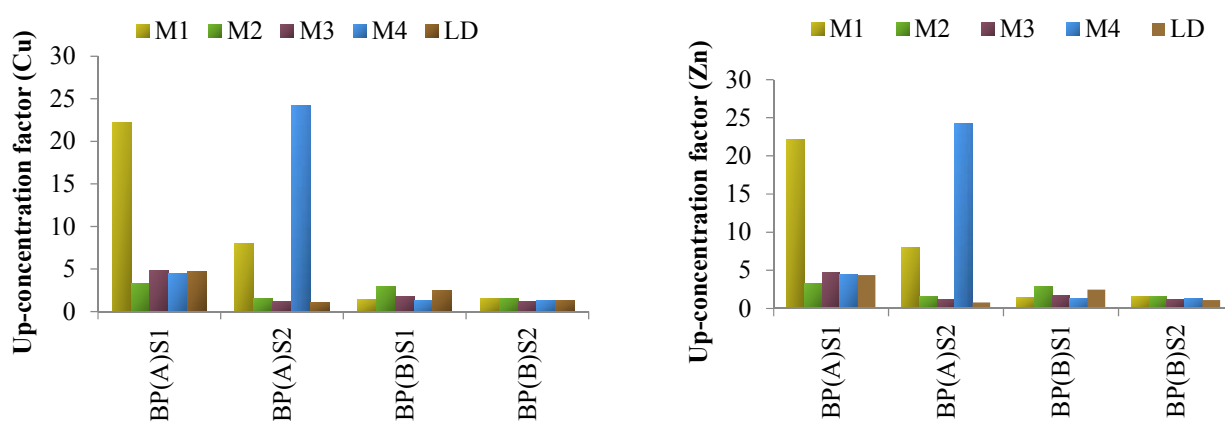


Figure 1. Comparison of differences in up-concentration factor between M1, M2, M3, M4 and laboratory data (LD) for Cu and Zn concentrations

Conclusion

The results indicate that Cu and Zn concentrations were higher in digestate arising from co-digestion unit where pig slurry is used as feedstock. Thus, the simulation result is highly influenced by the input stability (co-digestion versus mono-digestion). In order to minimize this impact, focus on individual input streams and their characteristics is needed. Mass reduction factor, in general, proved to be a good indicator of metal concentration in digestate.

References

European Commission, 2008. Waste Framework Directive 2008/98/EC of the European Parliament and of the Council of 20 December 2008 on the waste management requirements. Official Journal of the European Union, 312, 3-28.