Occurrence of organic contaminants in digestates: fate during process and after soil spreading

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Anthropic activities generate a full diversity of liquid and solid wastes that main contain hazardous compounds. Particularly, domestic/urban but also livestock wastewaters and their residual solid wastes (sludge and manures) are depicted as a reservoir of a huge diversity of organic contaminants (OC). Biowastes and green wastes may also contain some OC. All these raw or treated wastes are used as fertilizers or organic amendment onto soils. The presence of OC in these soil fertilizers/amendments may be shown as a real drawback of the practice due to their possible transfer from soil to plant/animal/human and water cycle. Anaerobic digestion is one way to treat organic wastes before their disposal on soil. Thanks to a literature survey, the present paper describes the occurrence of OC in raw and anaerobic treated wastes, emphasizes the dissipation mechanisms occurring during the process and after soil spreading.

A large number of OC has been quantified in raw and treated wastes, but the most studied ones are those regulated by states, including persistent compounds such as PAH, PCB, PCDD/F but also non-persistent such as detergent (nonylphenols, linear alkyl benzene), plastifiers (phthalates). Since around 10 years, other OC were studied like pharmaceuticals, flame retardants, perfluorinated compounds, polychlororinated n-alkanes, polymers…. The most studied wastes are sludge and livestock wastes on which OC are quantified either in raw or treated (biologically and physico-chemically) wastes. Biowastes, green wastes, residual household wastes and industrial wastes and their associated digestates and composts are less studied (Brändli et al., 2005). As shown on figure 1.1a and b, sludge are quite well described with a huge diversity of OC and concentrations varying from 10 ng/kg DM to 10 g/kg DM.

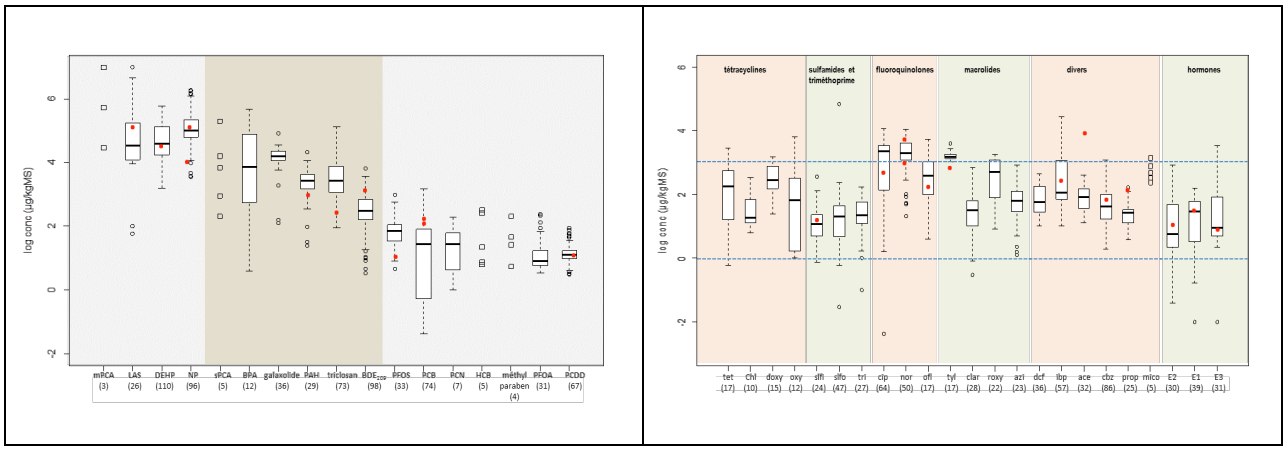

Figure 1.1. Organic contaminants in raw and treated sludge. In brackets: number of data used for box plot. Red points: French data.

Based on the survey, the impact of anaerobic treatment on the OC sludge concentration (mg/kgDM) is depicted with an increase of concentration (DEHP, NP), a decrease, or no difference. They are very few lab-scale or industrial scale

experiments dealing with the fate of OC during anaerobic digestion (Trably et al., 2003; Carballa et al., 2007; Barret et al., 2012; Mailler et al., 2014). All underlined the necessity to make a complete mass balance and very few depicted the real mechanisms behind removal which could be volatilization, transformation (with by-products) or bound residues formation (comparison abiotic/biotic systems, radiolabelled assays) (Barret et al., 2010). We could indeed improve the removal by increasing sorption to particules under non-extractable forms (the molecules can be trapped into the organic matrix and then will not transfer to water or biota) or increasing biodegradation (through (co)metabolism). In order to optimize these processes, it is important to better describe the pollutant bearing phases and assess their fate during treatments. More than only considering the aqueous and particulate partition, we have proposed to characterize the particulate bearing phases for OC during anaerobic digestion of sludge.

The behavior of PAH was experimentally studied during lab-scale continuous anaerobic digestion. At the same time, the fate of organic matter was studied during the treatments. To go further in the understanding of OC dissipation mechanisms, the organic matter was fractionated with successive chemical extraction simulating decreasing potential accessibility to degrading microorganisms (Muller et al., 2014). Each extracted fraction was characterized in terms of organic carbon, chemical oxygen demand and 3D fluorimetry. After each step of fractionation, OC concentration was determined in the residual solid phases in order to get their partition within the different compartments and finally to link this partition either to organic matter characteristics or to dissipation mechanisms. The same experiment was also realized with ^{14}C-fluoranthene. The evolution of organic matter fractions and partition of OC into organic matter fractions allow us to better understand the PAH dissipation pathways. These experiments are also conducted with pharmaceuticals compounds (Aemig, 2014).

They are very few data on the OC soil fate link to anaerobic digestion. Few studies exist estimating the contribution of different sources within the overall movement of OC in soil (Brändli et al., 2007). Studies of fertilizers application according to specification do not show OC accumulation in soils, although low levels of transfer into waterways or plant are likely (Sabourin et al., 2012; Prosser et al., 2014).

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