Influence of drying conditions on the survival of pathogens in dried digestates

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CONTEXT AND OBJECTIVES

- Digestates, the nutrient-rich by-products remaining after the anaerobic digestion, are commonly used as soil improvers or organic fertilizers.
- Drying is a potential post-processing treatment for concentrating the nutrients and reducing the cost of transport while stabilising and even sanitizing the digestates. Within the framework of the DIVA project, funded by the French National Research Agency, our objective was to assess the energy and environmental issues regarding digestate convective drying.
- The present work focuses on the thermotolerance of *Clostridium perfringens*, a grampositive, spore-forming, rod-shaped, non-motile bacterium, often used as an indicator to measure the efficiency of inactivation treatments.

Parameter	Value	Standard
Dry matter (%)	22.7	EN 12880
Total Kjeldahl nitrogen (wt %/dried matter)	6.13	AOAC 978.02
Ammoniacal nitrogen (wt %/dried matter)	2.72	AOAC 973.49 & EPA 350.2
Total carbon (wt %/dried matter)	43.1	NF-EN 13137
Organic matter (wt %/dried matter)	77.1	EN 12879

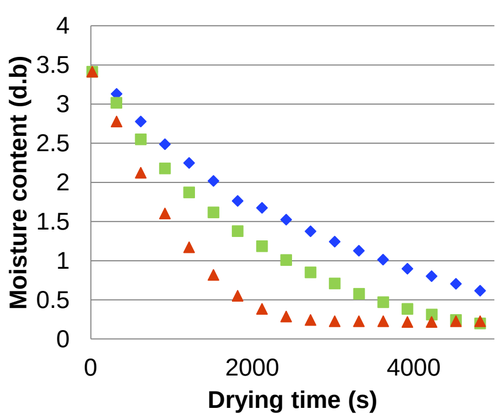
MATERIALS AND METHODS

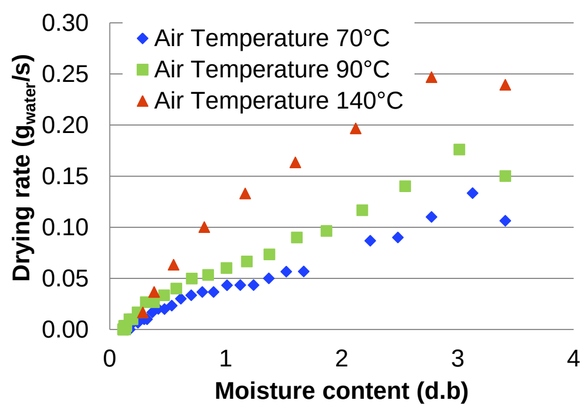
- The digestate was sampled in a plant processing pig liquid manure with residues from the agro food industry. After 60 days of digestion and 15 days of post-digestion, the digestate is dewatered in a decanter centrifuge before sampling.
- The samples were extruded through a disk with circular dies of 12 mm, forming a bed of extrudates on the dryer perforated grid. The initial mass of the bed was fixed at 500g.
- Drying experiments were conducted in a discontinuous pilot-scale dryer reproducing most of the operating conditions prevailing in a full scale continuous belt dryer. Constant air temperature (70 – 140°C), humidity (0.01 - 0.023 kg/kg d.a) and superficial velocity (1 - 2 m/s) were set at the inlet of the through-flow drying chamber.
- *C. Perfringens* were quantified following NF EN ISO 7937 standard in the raw and partially dried digestates. Thermo-tolerance is represented by the decimation time, D_T, in the first-order decline in microorganism population, N.

$$\log_{10}\frac{N}{N_0} = -\frac{t}{D_T}$$

RESULTS AND DISCUSSION

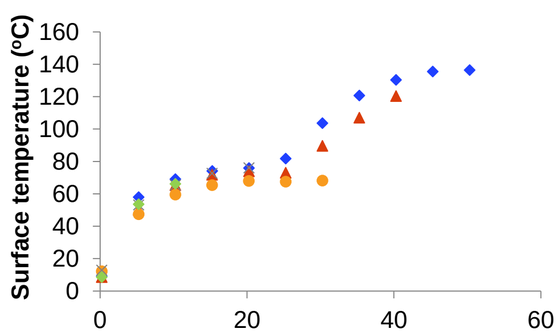
The drying rate curves are similar to those classically observed for municipal sewage sludge.

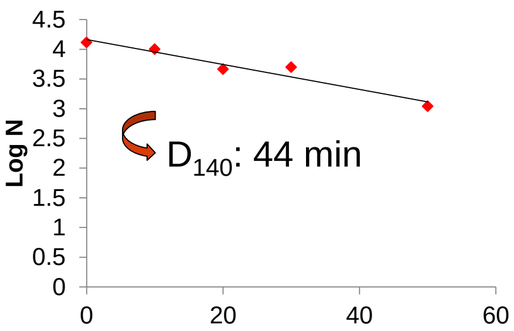




After a period of adaptation, the curves exhibit a narrow plateau, which is quickly followed by a long falling rate zone. Pure internal transfer limitations appear for a moisture content close to 0.7 (d.b.).

The drying experiment in the *a priori* most favourable conditions for pathogens inactivation (T_{air}=140°C, Y=0.0223 kg/kg and V=2 m/s) was selected for *C. Perfringens* enumeration. The different exposure times ranged from 10 to 50 minutes.





At 140°C for 44 minutes, drying induces a reduction in the concentration of *C. perfringens* by 1 $\log_{10}$ unit. At 70°C, the same fall in concentration is achieved after 128 minutes.

CONCLUSIONS

Log_{10} reduction of *C. perfringens* shows a linear decline over time, whatever the drying conditions. At 140°C, the digestate reaches a dry solid content of 82% after 50 minutes. Even if the product temperature is quite high after 30 minutes of drying, *C. perfringens* is still detected in the dried digestate. Convective drying has proven to be inefficient to inactivate *C. perfringens*, whatever the time-temperature conditions investigated (70°C for 3.5 hours or 140°C for 50 minutes).

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