Legacy Effects Override Edaphic Factors Determinants of CO_2, and N_2O, but not CH_4 Flux from Soil Following Digestate Application

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Introduction

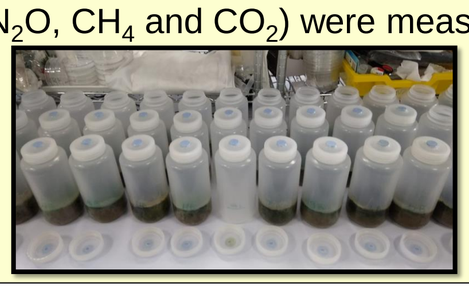
- Many authors have shown that digestate can be used as a nutrient source for crop production (Möller & Müller, 2012; Alburquerque *et al.,* 2012 ab; Barbosa *et al.,* 2014; Koszel & Lorencowicz, 2015)
- When digestate is applied to soil it can stimulate soil GHG fluxes (Czubaszek *et al.,* 2018). The relative importance of different soil parameters as determinants of soil GHG flux following digestate application remains unclear.

Aims:

- Quantify the impact of digestate after its application to soil in terms of emissions into the atmosphere.
- Quantify the soil GHG flux from soil amended with digestate.
- Investigate whether the legacy of the previous soil treatments is more important than edaphic factors in terms of greenhouse gas flux following anaerobic digestate application.

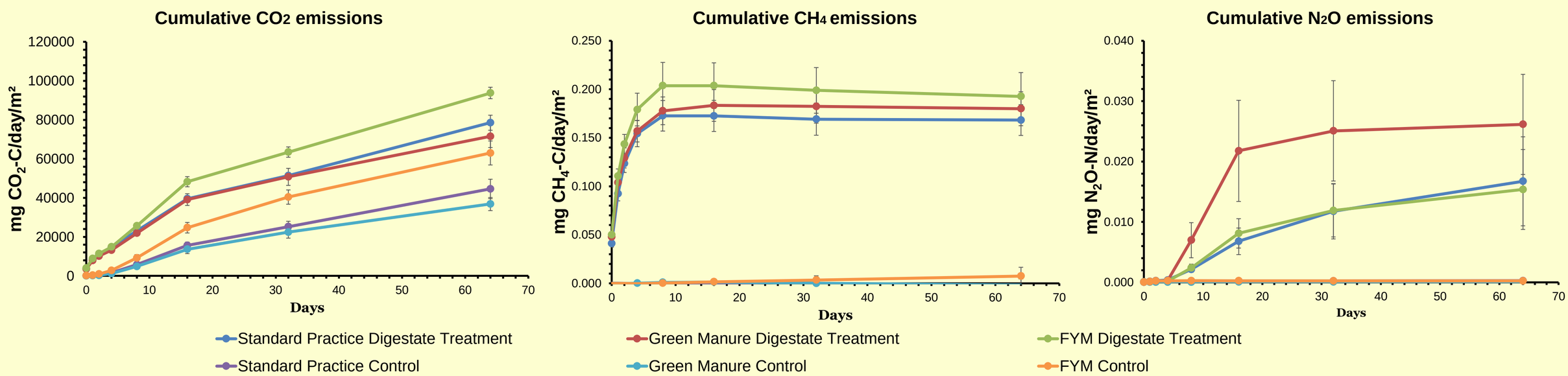
Methods:

- A cattle slurry digestate was applied to soil collected from a previously experimental field experiment with the treatments Standard Practice, Farm Yard manure (FYM) and Green manure (GM - 50:50 mix of fodder radish and vetch).
- The soil was packed into pots and watered to reach 60% water filled pore space (WFPS).
- Digestate was applied at a rate equivalent to 250 kg/ha of N.
- Gas fluxes (N_2O, CH_4 and CO_2) were measured on Day 1, 2, 3, 4, 8, 16, 32 and 64.



Results and Discussion

- The presence of digestate increased the flux of all three gases compared to the control.
- CO_2 flux: the legacy of previous soil amendments was a stronger determinant of flux than edaphic factors ($P < 0.001$).
- CH_4 flux: soil texture significantly interacted with previous management practices and digestate application as determinants of CH_4 flux ($P < 0.001$).
- N_2O flux: the legacy of previous soil amendments was a stronger determinant of flux than edaphic factors ($P < 0.001$).



FYM application significantly increased CO_2 flux following digestate application. This suggests either the microbial biomass increased or the microbial community changed in such a way that it was able to respond faster to the labile carbon supply.
As for the N_2O flux, vetch like other legumes, adds nitrogen to the soil by means of nitrogen-fixing bacteria. This data suggest that this may have primed the soil such that N was cycled faster under this treatment when digestate was applied thereby increasing N2O flux from soil of this treatment.

Implications for farming: Sustainable agriculture requires the efficient use and cycling of nutrients. However, it is also necessary to reduce the amount of GHG emissions generated by agriculture to help mitigate climate change. Understanding the interactions between soil factors and the legacy effects of previous soil amendment practices is essential in order to improve agricultural efficiency and sustainability.

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Evaluation of soil health following digestate application using QBS-ar index and Solvita

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Introduction

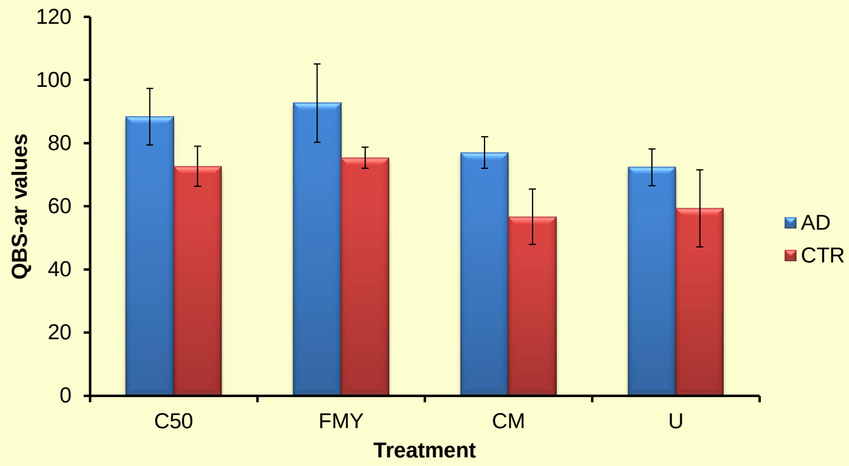
- Anaerobic digestates are useful nutrient sources for crop production (Barbosa *et al.,* 2014; Koszel & Lorencowicz, 2015).
- Solvita: the Solvita Soil Respiration System (Solvita) is a tool to evaluate soil microbial respiration rates in a cost-effective manner (Doran et al., 1997). The rate and quantity of CO_2 release over a specific period is generally regarded as an accurate indicator of biological attributes favoring healthy soil functioning (Solvita & Woods End Laboratories, nd).
- QBS-ar: the number of microarthropod groups morphologically well adapted to the soil is higher in high quality soils than in low quality soils. The overall mean **93.7** defines a partition between soils that are commonly associated to good quality from those that are degraded or managed (Menta et al., 2018)

Aims:

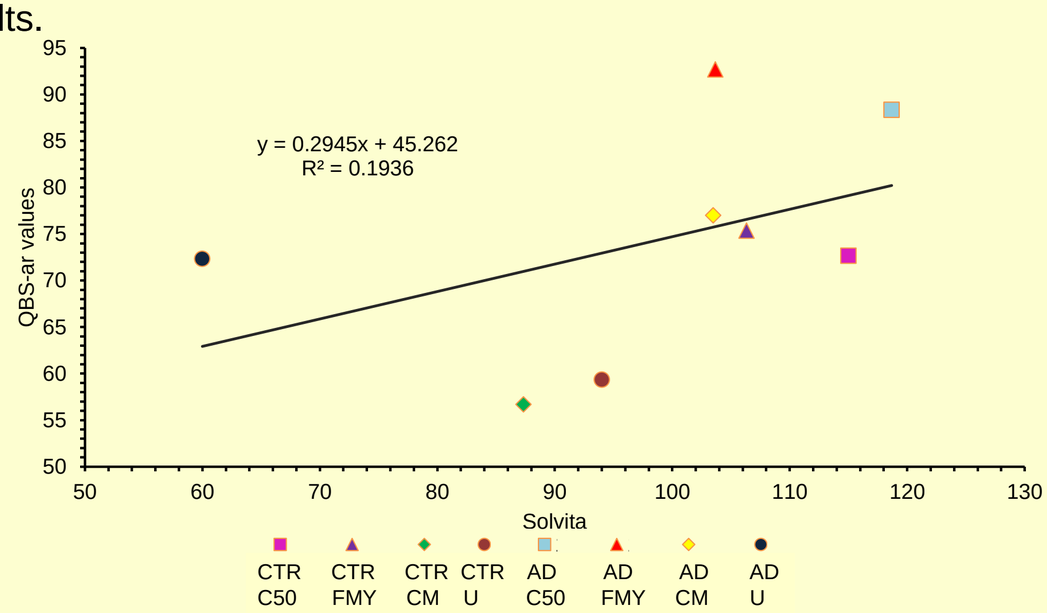
- evaluate soil heath of an already established field experiment following the application of digestate using QBS-ar index and Solvita test;
- compare QBS and Solvita results to evaluate whether they are both good methods to be used in the evaluation of soil health.

Results

The QBS scores are on average below 93.7. This suggests relatively low levels of soil health. There is a trend for digestate to increase soil health as measured by QBS-ar, reveling a more complex arthropods community in digestate- amended plots.



No significative correlation was found between QBS-ar index and Solvita results.



CTR = Control **AD** = Digestate **C50** = Compost **FYM** = Farmyard Manure **GM** = Green Manure **U** = Untreated

Methods:

- 24 soil samples (12 control, 12 digestate-amended, of which ¼ untreated, ¼ compost, ¼ FYM, ¼ chicken manure) were collected from an agricultural field experiment located in Swindon, for the application of the QBS-ar index and Solvita.
- Solvita analysis were carried out from Agrii Company in Swindon: the flush of CO_2-C following rewetting of dried soil was determined. Soils were incubated at 25˚C and respired CO_2-C was measured after 24 h. The quantity of CO_2-C released was determined using a digital-color reader (DCR).
- Arthopods were extracted at Harper Adams University using Berlese-Tullgrenn funnels in order to apply QBS-ar index. EMI (Eco-morphological index) values where assigned to soil fauna in order to calculate the total QBS-ar value per sample, results by sum of EMI.

Discussion and Further Work

QBS-ar showed a good influence of digestate on soil fauna compared to control plots (p-value= 0.0078) regardless the previous management practices used. Digestate can be source of food for soil arthropods or it can create good conditions for these organisms to survive. Soil was dry at the time of the sampling and this can explain why the QBS-ar values in control plots were lower than expected (overall below 93.7). It can be hypothesised that digestate creates a more suitable environment for arthropods to survive under unfavourable conditions.

Solvita results showed a different pattern with a heavier impact on soil CO_2 flux associated to previous treatments (p-value=0.04) more than digestate application. The correlation found between QBS-ar results and Solvita is, in fact, very low (19%). Soil CO_2 flux can be highly dependent on the content of OM and soil texture (Fungenzi, 2015), therefore Solvita test can be considered not particularly robust for soil health measurements.

Further research on digestate-arthropods interaction need to be carried out as well as assessing whether Solvita methodology can be improved in order to be a better indicator of soil health.

Implication for farming: QBS-ar is an easily applicable index and it can be easily used as an indication of soil health overcoming difficulties related to complex taxonomic identifications. Digestate application can have an impact on biological activities and potentially improve soil arthropods community structure under unfavourable conditions.

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