

Methodological approach to identifying the properties of a novel organomineral fertiliser – Part II: environmental aspects and OMF application

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SUMMARY

This paper summarises the methodology used in this investigation to determine the potential environmental impact arising from the use of organomineral fertilisers (OMFs) in agricultural land by focusing upon two main subjects: NO₃-leaching and N₂O-emissions. In addition, the paper describes the method that will be used for the evaluation of spreading fertiliser equipment. It highlights the importance of achieving a high degree of uniformity when applying biosolids to agricultural land as one of the main factors controlling the agronomic efficiency of applied nutrients. Although experimental data are not available yet, the experiments are under construction, and it is the aim of this paper to gain criticism on the proposed methodological approach. Experimental data will be statistically analysed using analysis of variance and least significant differences to compare means.

Key words: nitrogen leaching, nitrous oxide emission, fertiliser spreading

INTRODUCTION

The application of sewage-sludge to agricultural land is a highly regulated activity (Evans, 1998). It is governed by the EU Sewage Sludge Directive 86/278/EEC which is enforced in the UK through the Sludge (Use in Agriculture) Regulations 1989. These are complemented by a number of regulations such as The Code of Practice for Agricultural Use of Sewage Sludge and the Safe Sludge Matrix among others. The position of the UK Government towards recycling has been clearly indicated. In this respect, the Government has committed to reduce the amount of waste landfilled to 75% of that produced in 1995 by 2010, and to cutback CO₂ emissions by 20% in 2010 (Defra, 2007); thereby, imposing increasing restrictions to disposal through incineration and landfilling.

Although the fertiliser value of sewage-sludge have been acknowledged (Milne and Cleveland, 1972); in practice, many farmers appear to be reluctant to applying biosolids to agricultural land. This is often due to the impracticality of having to deal with large volumes of materials to meet the nutrients' requirements of crops. The use of cakes in recent years addressed, to certain extent, some of the problems associated with liquid sludges; e.g. cost of transport and application.

However, the problem of delivering the desired application rates and achieving acceptable levels of uniformity across the working width of spreading fertiliser equipment, for instance, similar to those of mineral fertilisers applied with standard fertiliser spreaders, remains unsolved. This is aggravated by the fact that physical properties; e.g. particle size and composition of individual particles are not consistent. Uneven nutrient distribution can increase the risk of N-losses; e.g. nitrate leaching and gaseous losses, in areas where N is applied in excess of crop demand. The development of OMFs would contribute to address these issues by providing a product which has more consistent physical characteristics and known chemical composition (Antille *et al.*, 2008).

The aim of this work is to describe the methodology that will be used to quantify the losses of N from the formulated OMFs through both nitrate (NO₃) leaching and denitrification via nitrous oxide (N₂O). In addition, the paper explains how the OMFs' physical properties will be assessed in relation to the distribution pattern during application and the spreading equipment.

METHODOLOGY

OMFs' physical properties

There are a number of properties that control both the motion of individual particles and the resultant spread pattern. Hofstee (1993) indicated that the most important properties are: *a.* particle size and particle size distribution; *b.* coefficient of friction; *c.* aerodynamic resistance; *d.* coefficient of restitution; and *e.* particle strength. From these, *a*, *b*, and *c*, have the greatest influence on the spreading pattern (Hofstee, 1993). In addition, particle strength can alter the particle size distribution and affects the spreading pattern if segregation takes place (Bradley and Farnish, 2005).

Preliminary findings have shown that the formulated OMFs have a bulk density of 0.58-0.60 t m⁻³; this value is approximately 10% higher than that of digested cake. It appears that the blending process, during the OMF production, results in increased bulk density of the final product compared to the cake. The measured bulk density of granules of urea fertiliser gave an approximate value of 0.78 t m⁻³.

The particle size distribution was determined by sieving a sample of OMF and then weighting the sieved material; this was done for a number of sieves sizes ranging from < 1 mm to > 5.6 mm in diameter (**Figure 1**).

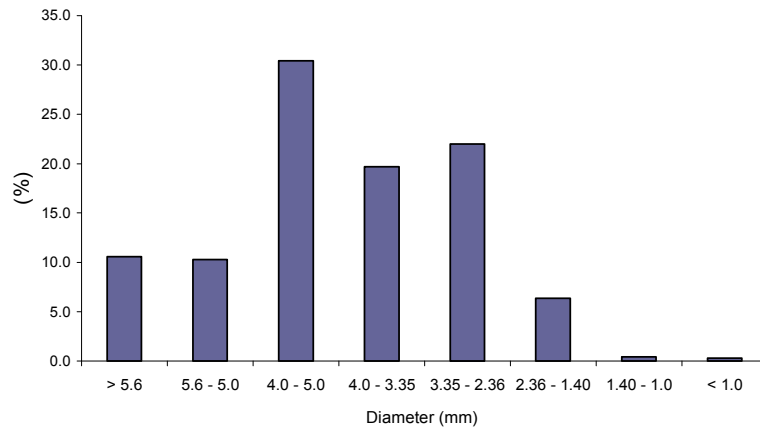


Figure 1: OMFs' particle size distribution.

The same was done for urea which gave, as expected, a much uniform particle size distribution with more than 92% of the particles in the range of 2 to 4 mm in diameter. Given that just over 40% of OMF particles fell into the desired size; i.e. 2-4 mm, a decision was made to discard all OMF particles outside this range in order to obtain a similar particle size distribution as urea. This approach means more processing during the OMF production but will ensure more uniformity in the final product (**Figure 2**).



Figure 2: OMF particles [100% between 2 and 4 mm in diameter].

This work is concerned with the optimisation of the particle shape, size, and size distribution, as these parameters can be easily adjusted during the OMF production. These properties will be then assessed by means of a spreading trial in the field. Details of this trial are given in the following section. In addition, it would be an advantage to measure the OMF breaking force to determine the relationship between the OMF particle strength and particle size. This relationship would provide a valuable indication on whether the OMF becomes stronger or weaker as the particle size is increased. Various strength measuring techniques are described by Hoffmeister (1979) and Rutland (1986).

OMF application

The most widespread methodology for measuring distribution uniformity and calibrating granular broadcast fertiliser spreaders is given by ASAE (1999) S341.2. The advantage of this method is that it allows to determine the performance of fertiliser spreaders when used for the application of granular fertilisers, and to compare different distribution patterns. The test consists of two parts: **1.** determination of application rate, and **2.** determination of distribution pattern. The rate is determined by measuring the amount of material applied divided by the area. The spread pattern indicates the degree of uniformity of distribution of fertiliser across the working width. This is determined by collecting and weighting fertiliser particles captured in trays placed across the swath being spread. The OMF products have been formulated for application rates of 1.2-1.4 t ha⁻¹; thus, the spreading equipment; i.e. Bredal K105 and Amazon ZA-M, will be first adjusted to deliver the desired rates and then the distribution pattern will be determined. Comparisons will be made with a standard fertiliser; e.g. urea. This test will provide valuable information regarding the spreading behaviour of this material, its interaction with standard spreading equipment, and the need for improving the OMF's physical properties.

Nitrogen leaching

Losses of applied OMF-N will be determined using lysimeters which were recently constructed at Silsoe Farm (**Figure 3**). Quantifying N-losses is important to anticipate the potential environmental risk associated with the use of OMFs. The design of the lysimeters is shown in **Figure 4**.

The experiment comprises the use of a sandy loam soil, OMF₁₅, urea, and a combination of urea and OMF₁₅ used as fertilisers materials which will be applied at only one rate of 240 kg N ha⁻¹, and a control with no fertiliser added, and two crops; i.e. spring wheat and grass. This design gives a total of 24 lysimeters. Each treatment will be replicated three times to facilitate the statistical analysis.



Figure 3: Overview of lysimeters' facility at Silsoe Farm.

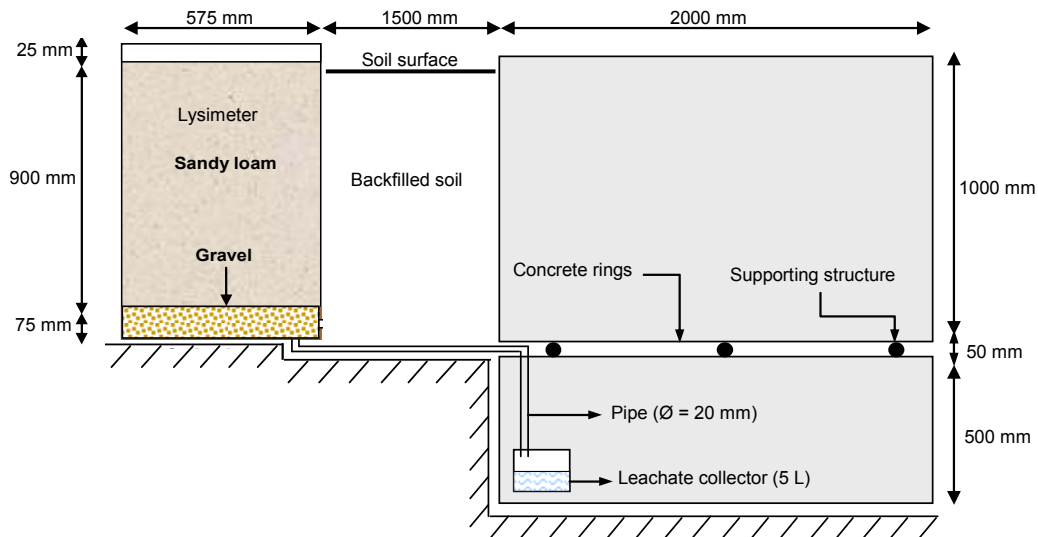


Figure 4: Diagram illustrating the lysimeters' design (side elevation).

Leachate will be regularly collected for determination of NO_3 . In addition, soil available-N will be determined before fertiliser application and at the end of the growing season to aid establishing a nitrogen balance in the soil. This information will be linked to measurements of N_2O -emission which are explained in the following section.

Nitrous oxide emissions

Nitrous oxide is a greenhouse gas for which inventories of emissions are needed to comply with the Kyoto Protocol 1997 (Smith and Dobbie, 2001). At present, there is limited amount of information available on N_2O -emissions after sewage-sludge application to agricultural land (Le, 2008). There is also no evidence of research being undertaken to determine N_2O -emissions after OMF application. The purpose of this experiment is to quantify N_2O -emissions following OMF application on spring wheat and grassland. Measurements will be taken for a period of 12 months to account for temporal variability. In this experiment, an automated closed-chamber developed by Smith and Dobbie (2001) will be used. The chambers will be placed on top of the lysimeters to facilitate the linking of these data to that of leaching. Samples will be collected for gas chromatographic analysis at ADAS-Boxworth. Full details of the chambers are given in Smith and Dobbie (2001).

CONCLUSIONS

The development of OMFs will contribute to address some of the issues related to the application of sewage-sludge to agricultural land. Improving the physical characteristics of the product is crucial to delivering the desired application rates.

This is important to optimise the economic return from the use of fertilisers and reduce nutrient losses. Quantification of N-losses is important to develop appropriate fertiliser application strategies, protect the environment, and ultimately, improve the agronomic efficiency of applied nutrients.

ACKNOWLEDGEMENTS

The authors would like to thank the sponsoring company, United Utilities plc, and the Engineering and Physical Sciences Research Council (EPSRC) for their financial assistance, Cranfield University staff for their help during the construction of the experiments, and Dr. Rachel Thorman (ADAS-Boxworth) and Mr. Anthony Dale (Dale Contractors) for many useful suggestions concerning this work.

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