Pig slurry as organic fertiliser: a cooperative project

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Abstract
In Murcia, SE Spain, the number of intensive pig farms has increased in the last 20-25 years. They are concentrated in a small area, and slurry management has become an important problem for the farmers. The agronomical use of these organic wastes contributes to the reduction of gas emissions, the restoration and reclamation of agricultural and marginal lands, improve the amount and quality of stable organic matter and fights against progressive desertification processes. For this reason, a project has been created where farmers can use the manure stored in pig farms as an organic fertiliser. In this way, slurry and soils samples have been analysed to understand their physical and chemical characteristics before and after use as a soil amendment. Then, pH, electrical conductivity (CE), N content, P content and organic C, were studied in order to determine the application dose for agricultural soils.

Key Words
Manure management, agricultural use, slurry pig, organic fertiliser.

Introduction
Intensive and industrial systems have enormously increased the numbers of animals farmed globally and will continue to do so. On intensive pig farms, the animals are generally kept on concrete with slats or grates for the manure to drain through. The manure is usually stored in slurry form (a liquid mixture of urine and faeces). One possible solution for this problem is to incorporate manure immediately into the soil following field application. But in some regions the soils, because of coarse texture or drainage characteristics, are not suitable for utilizing hog manure effectively as a nutrient resource, and this problem results in a risk of pollution of water by nitrogen and phosphorus. Therefore there is a need to develop manure application guidelines so that manure nutrients are applied at rates not exceeding the capability of specific crops to utilize these nutrients. The availability of plant nutrients from manure depends on its composition and on other factors such as management practices and soil characteristics. Thus, the main objective of this work was to find out a practical solution for waste manure management for pig farmers in order to find an economical solution for organic fertilization and avoid the nitrogen and phosphorus pollution of land and water.

Methods
This work was carried out in the region representing the first area in Murcia, SE Spain, with the highest pig production, as well as is the most important horticultural area. In this way we established a system that put in contact pig farmers with farmers to collect the slurry storage for their evaluation and land distribution. The soil and pig slurry samples were collected in two consecutive years, 2008 and 2009.Soil samples were collected at surface level and at a depth of 30cm, with and without slurry application in order to see the influence of this application in soil composition. All the samples were analyzed by standards methods to obtain the texture classification for determining soil suitability for manure application, values of total N (Duchafour 1970), pH (Peech 1965), electrical conductivity (Bower and Wilcox 1965) and total P (Watanabe and Olsen 1965).

Results
Table 1 to 4 show the values of pH, electrical conductivity (EC) and total nitrogen, as well as the total phosphorous (Watanabe and Olsen, 1965) in soil and each slurry pond studied. The N maximum dose of application is mandatory regulated (RD 324/2000) and established as 170 kg /ha/year in special sensitive areas. In this work the dose of slurry to apply has been calculated based on N content.

The pH values ranged from 7.6 to 8.3 corresponding with a basic soil (Porta *et al.* 1999). The electrical conductivity ranged between 1.5 and 0.2 dS/m at 25ºC with similar values from surface to 30 centimetres depth. Changes in the chemical composition of the soil caused by application of manure are much influenced by factors such as soil texture, rate, time and method of application of manure, the amount of local precipitation,

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Table 1. pH and EC (dS/cm) soil data values obtained for samples collected in 2008.

Farmer	F1		F2		F3		F4	
	Top	Depth of 30cm	Top	Depth of 30cm	Top	Depth of 30cm	Top	Depth of 30cm
pH	7.83	8.19	7.81	7.86	8.35	8.09	7.64	7.8
EC (dS/m)	0.94	0.46	1.20	1.54	0.20	0.68	0.88	1.11

Table 2. Slurry data obtained for samples collected in 2008.

Pig farmer	pH	EC (dS/m)	NA (g/L)	NT (g/L)	P (mg/L)
PF1	6.36±0.03	30.27±0.21	2.12±0.09	2.46±0.54	94.00±28.8
PF2	8.49±0.07	44.83±0.74	5.22±0.12	7.14±0.20	134.7±4.0
PF3	8.19±0.15	25.73±0.32	3.00±0.04	3.95±0.14	177.5±25.5
PF4	7.91±0.06	33.80±0.42	3.31±0.42	5.05±0.17	207.00±33.0

Table 3. pH and EC (dS/cm) soil data obtained for samples collected in 2009.

Farmer	F1		F2		F3		F4	
	Sup	Depth of 30cm	Sup	Depth of 30cm	Sup	Depth of 30cm	Sup	Depth of 30cm
pH	7.83	8.19	7.81	7.86	8.35	8.09	7.64	7.8
EC (dS/m)	0.94	0.46	1.20	1.54	0.20	0.68	0.88	1.11

Table 4. Slurry data obtained for samples collected in 2009.

Pig farmer	pH	EC (dS/m)	NA (g/L)	NT (g/L)	P (mg/L)
PF1	7.12±0.06	27.75±0.919	2.15±0.63	2.51±0.68	100.2±0.10
PF2	7.79±0.01	55.10±0.1	6.33±0.01	4.58±0.25	290.7±0.29
PF3	6.95±0.04	36.50±0.1	2.79±0.07	3.12±0.05	397.0±0.39
PF4	7.44±0.04	26.53±1.6	2.48±0.02	2.93±0.02	110.7±0.11

and the crops grown, as well as the animal and farm management. With respect to total N content the data showed that the highest concentration of N is also located in the surface for both studied years, even when samples from application area and non application were compared (2.172-0.875 g /kg in 2008, and 1.528-1.025 g/kg in 2009). The levels of total N have no statistical differences before and after slurry application. In both cases the N concentrations were lower than 0.5 % that is the maximum level for agricultural soils (Andrades 1996). Heavy application of manure has been shown to increase NO_3-N and available P more rapidly than inorganic fertilizers. Manure application also results in accumulation of NO_3-N, and extractable P in the subsoil (Pries 1996). The level of accumulation increased with the rate of application, but in this study the dose applied is low according with the law.

Hog manures have a lower N/P ratio than crop plants. Thus when N is supplied through manure to a crop, more P is applied than is required by the plants and this may result in leaching and runoff of P. If Figure 1 and 2 are compared, it is possible to show the increase of P content after slurry application. This is because the traditional application rates are based on N needs for the crops. This has led often to an increase in soil P level in excess of crop requirements because of the greater N-to-P ratio (average ratio of 4:1).

The texture analysis (Table 5) showed that the predominant textural classes of analyzed soils were clay, clay loam and silt-loam, except for F3 where sand is the predominant textural class (coarse-textured). These results

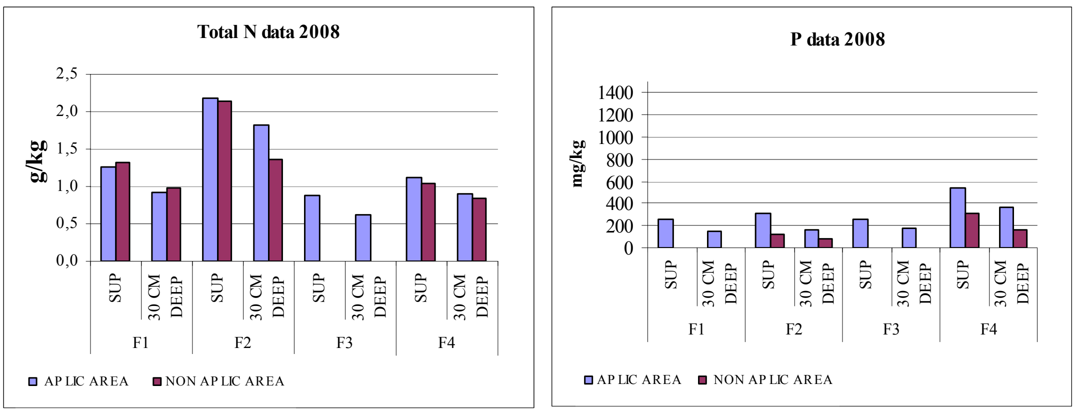

Figure 1. Graphic representation of total N and soil and P_2O_5 soil data values in mg/kg, obtained for samples collected in 2009

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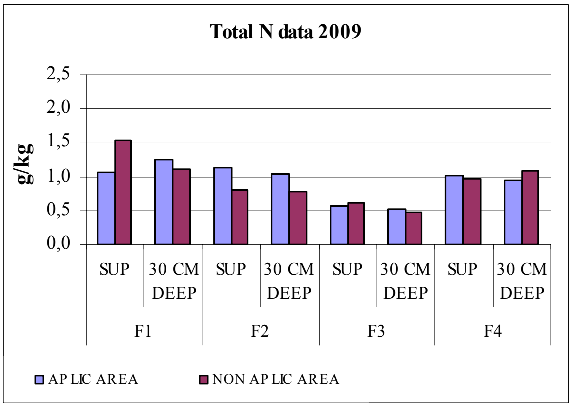

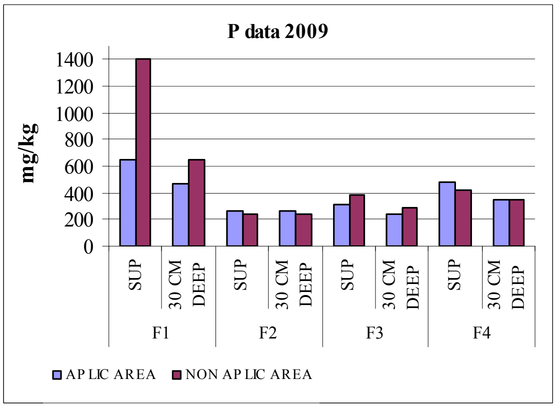

Figure 2. Graphic representation of total N and P_2O_5 soil data values in mg/kg, obtained for topsoil and subsoil samples collected in 2009.

Table 5. Summary of textural classes for soil samples.

Farmer	Topsoil sample	Depth of 30 cm sample
F1	Silt-loam/Clay-loam	Clay-loam
F2	Silt-clay	Silt-clay
F3	Loamy-sand	Loamy-sand
F4	Silt-clay	Silt-clay

confirm they are heavy-textured soils that have low permeability and promote low rates of decomposition; then high application rates of manure on heavy-textured soil may be beneficial because of the high nutrient-holding capacity of these soils. It is possible to appreciate that F3 presents low value for both parameters (N and P), due the coarse-textured soils that are highly permeable and promote rapid decomposition of manure. High application rates of manure to coarse-textured soil may contaminate groundwater through the leaching of nutrients (Vanderholm 1975). However, information on the effects of hog manure on soil physical properties is limited. When slurry data are studied (Table 2 and 4) they show that the composition of analysed samples is different for 2009 as compared to 2008, what can be explained by changes that occur from one year to another in handling, animal feeding and cleaning of facilities. These changes are related to several circumstances (economical situation, weather conditions, sanitary conditions, etc.). However, the amount of nutrients in soils seems not to be influenced by slurry composition.

Conclusions

Hog manure should be regarded as a resource, and its management and utilization should be approached accordingly. Application to cropland is one of the most obvious methods of recycling plant nutrients. Soil suitability for hog manure application is a national and international issue. The common method of determining application rates is currently based on the capacity of the crops to take up the nutrients, most often on the N requirement for the selected crop. Plant nutrients removed from the soil in the harvested product fed to the animals are then returned in part to the soil as manure. An effective and easily achievable strategy to reduce the slurry pig accumulation is to apply to on agricultural soils, but it is important to take in account their characterization and valorisation before application.

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