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Total and faecal coliform bacteria persistence in a pig slurry amended soil☆

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Abstract

The aim of this experiment was to study the effect of the application of pig slurry on potential pathogen (total and faecal coliform bacteria) presence in a Typic Xerofluvent soil. The experiment was conducted in field conditions, in the Segura River valley in the South East of Spain. Four treatments, in a fully-randomised design with three replicates per treatment, were established in experimental plots of 16 m^2 each. Fertiliser treatments were: MF, mineral fertiliser (with a complex 16N–16P_2O_5–16K_2O) equivalent to 150 kg N ha^{-1}; PSF, organic fertilisation with swine manure slurry, at two different rates (supplying 150 and 210 kg N ha^{-1}), and C, a controlled treatment without fertilisation. A high variability of the concentrations of total and faecal coliforms was observed during the experiment, mainly depends on the time and the treatment. The pig slurry amendment induced the highest initial and also persistent presence of total and faecal coliform bacteria. The higher application rate seemed to induce a long-lasting persistence of the total, but especially the faecal coliform, population in the amended soils compared to the lower rate. In most cases, an increase in the total coliforms content was observed in the soils amended with mineral fertiliser compared to controlled soils, probably due to an increase in soil microorganisms populations. In general, the total coliform bacteria was 2–3 $\log_{10}$ units higher than the faecal ones. Mostly, a tendency to decrease with time was observed in both indicator microorganisms, in all the treatments.

Keywords: Pig slurry; Soil; Faecal coliforms; Survival

1. Introduction

The increase in the number of industrial farms, without soil nearby, represents an opportunity to re-use their residues for agricultural purposes, as a source of nutrients and organic matter. Recent manure production within Spain has been approximately 190×10^6 t $year^{-1}$ (Water Research Centre, 2001).

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In the Vega Baja area, in the Valencia State of Spain, piggeries are an increasing activity. In this area, over 120 pig farms were identified, with an estimated total annual production of pig slurries of over 70,000 m^3. The management types in these farms and the relative pig slurry productions (% in brackets) were: completed cycle, 43% (49%); nursery, 16% (17%); semi-completed cycle without fattening, 32% (28%); just weaners, 9% (6%). The relative pig slurry production as a function of production stage in the studied farms was: finishers (34%) > gestating sows (29%) > weaners (18%) ≈ farrowing sows (18%). In the majority (95%) of the farms, the management system is based on dry-feeding with pellets and/or flour.

The agricultural use of these manures is recommended, not only for fertilising but also to facilitate the disposal of these increasingly important residues. Characteristics of pig slurries in the studied farms in Southeast Spain were similar to those reported previously in other countries (Italy, United Kingdom, Germany, Ireland) (Moral et al., 2005).

Faeces, urine, uneaten food and bedding from intensively-farmed pigs are usually collected as slurry and stored in lagoons, pits or above-ground tanks until field conditions are suitable for application to agricultural land (Turner and Burton, 1997). However, animal wastes may contain pathogenic organisms and contribute to agricultural non-point source pollution (Reddy et al., 1981). Microbial loads in excess of the levels allowed in human wastes have been found in land-applied liquid animal wastes (Crane et al., 1983; Gessel et al., 2004). Faecal bacteria can also contaminate streams and groundwater via runoff and leaching from agricultural areas if management is improper (Crane et al., 1983; Meinhardt et al., 1996). Coliforms are usually present in pig slurries and, although different authors have reported that the survival time of coliforms in soils is relatively short (1–2 months), a regrowth of these indicators in the amended soils is possible. Gibbs et al. (1997) concluded that soil amended with biosolids could not be considered free from pathogens and indicator organisms (faecal coliforms, faecal streptococci and salmonellae) for at least one year following amendment. Low temperatures, high humidity and neutral soils generally help the growth and survival of enteric bacteria. The aim of this experiment was to study the effect of the application of pig slurry on total and faecal coliform bacteria presence in a Typic Xerofluvent soil with a highly-intensive agricultural use.

2. Materials and methods

The experiment was conducted in field conditions, in the Segura River valley in the South East of Spain. Four treatments, in a fully-randomised design with three replicates per treatment, were established in experimental non-cultivated plots of 16 m^2 each, with 0.5 m between plots. Fertiliser treatments were: MF, mineral fertiliser (with a complex $16N–16P_2O_5–16K_2O$) equivalent to 150 kg N ha^{-1}; PSF, organic fertilisation with swine manure slurry, at two different rates (supplying 150 and 210 kg N ha^{-1}, equivalent to 70.6 and 98.8 m^3 ha^{-1}), and C, a controlled treatment without fertilisation. The pig slurry, from a farm with

Table 1
Main characteristics of the soil and the pig slurry applied

Soil		Pig slurry	
pH	8.79	pH (20 °C)	7.80
Electrical conductivity (dS m^{-1})	0.21	Electrical conductivity (dS m^{-1})	19.46
Sand (%)	35.2	Suspended solids (mg L^{-1})	10,250
Silt (%)	34.9	Redox potential (Eh) (mV)	−280
Clay (%)	29.9	Density (g cm^{-3})	1.012
Texture	Clay loam	Dry matter (g L^{-1})	12.9
Total $CaCO_3$ eq. (%)	36.1	BOD_5 (mg O_2 L^{-1})	5000
Active $CaCO_3$ eq. (%)	10.1	COD (mg O_2 L^{-1})	16,613
Organic oxidisable C (g kg^{-1})	8.33	Kjeldahl N (mg L^{-1})	2125
Kjeldahl N (mg kg^{-1})	1190	Ammonium N (NH_4^+–N) (mg L^{-1})	1767
Dry matter (%) range	10–15	Total coliform (CFU mL^{-1})	5×10^5
		Faecal coliform (CFU mL^{-1})	8×10^3