Leaching of nitrate due to the fertilization with litter of swine bedding, liquid swine manure and chemical fertilizer

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Abstract
The successive application of high doses of pig manure can lead to contamination by nitrate, due to the high nitrogen concentrations in these wastes, related primarily to the composition of the diet of pigs. This study evaluated changes in levels of N- NO_3^- in an Ultisol, in the city of Braço do Norte, SC, during the cycle of culture of maize in a tillage system, in relation to fertilization with litter of swine bedding, liquid swine manure and chemical fertilizer, with application of the appropriate dosage of N and twice the recommended dosage for maize. The evaluations were made at soil depths of 0-15, 15-30, 30-45 and 45-60 cm at six dates during the maize cycle. There were increases in the levels of NO_3^- in the soil, with variation of values during the cycle of the culture. The highest value was observed in the treatment fertilized with pig slurry 2x at the depth of 45-60 cm. The results indicate the occurrence of leaching of NO_3^-, but this nitrate is not yet present at critical levels in the soil.

Key Words
Swine, percolation, fertilization.

Introduction
Santa Catarina is a large producer of pork where like in other countries, the activity is typical of small farms. Often the land available for disposal of waste generated in production is insufficient, leading to successive applications in small areas. The fertilization of agricultural land with swine manure can be an important source of nutrients, which when properly managed provides an increase in productivity. However, current practices and incorrect handling of these wastes contribute to the degradation of the soil, water and air quality, mainly by contamination of the groundwater. Thus the swine culture in confinement is considered by the agencies of environmental management as an activity of high polluting potential (Pereira 2006). The chemical characteristics of wastes are related to the nutritional composition of diets of the swine, among other nutrients, is rich in N, P and K, with 60 to 70% of the N ingested by the animals being excreted in their faeces and urine (Oliveira 2000). Among the macronutrients present in the manure, N is usually the element in highest concentration and also the one that causes the largest environmental problems, caused by changes to the soil and may result in losses, mainly by leaching. The process of nitrification of the ammonium nitrogen in the manure applied to the ground occurs quickly, and can exceed the capacity of absorption by plants and microorganisms, decreasing the potential fertilization by the waste and/or increasing the pollution by potential (Franchi 2001; Aita and Giacomini 2008; Giacomini and Aita 2008). Giacomini and Aita (2008) observed that with the application of pig slurry, mainly in a dose of 80 m^3/ha, the quantities of N-and NO_3^- and their leaching in the soil increased rapidly after the application of manure. Therefore, knowing the destination of these elements in the ground is essential for assessing the environmental impact caused by the use of the manure and its impact is directly related to the soil's ability to retain the NO_3^-. This study aims to evaluate the levels of ammonium in the soil and leaching of the nitrate, at depths of 0-15, 15-30, 30-45 and 45-60 cm, in an Ultisol Red-Yellow fertilized with pig bedding, liquid swine manures and chemical fertilization in SPD, since 2002, in the city of Braço do Norte, SC.

Methods
The experiment was installed in the year 2002 in an Ultisol Red-Yellow, cultivated under a system of no-tillage with the succession oats / maize without the use of pesticides in a rural property located at the Watersheds River Cachorrinhos, in the city of Braço do Norte, SC, with coordinates 28º 15 'S and 49 º 15' W. The climate of the city is a Cfa type, according to the classification of Köppen (Epagri 2000). The treatments were applied in experimental units (parcels) of 4.5 x 6.0 m (27 m^2), constituted of: control (T) no fertilization, fertilization with swine bedding (CS), fertilization with pig slurry (DL), nitrogen soluble (AS) with urea application with three replications. All the fertilization treatments were applied with doses related

to one (1x) and two (2x) times the N recommended for culture of oats and maize. The applied values were calculated based on the Chemical Commission and Soil Fertility (CQFS RS / SC 2004). The amount of N recommended for the cultures (30 kg/ha for oats and 90 kg/ha for maize) was defined in function of the soil analysis and productivity expected of maize. The swine bedding was manually applied on the soil surface, five days before planting the maize. The application of liquid swine manure and soluble fertilizer (urea) was according to the recommendation of the CQFS RS / SC (2004). The liquid manures were collected in a midden system located in the same property. The volume of manure applied, determined from the estimated concentration of nutrients by the densimeter calibration, was 50.9 m^3/ha for the treatment once (1x) the need of N for the crop, distributed in three applications (01 / 10, 05/11 and 23/12/2007). The total amounts of nutrients applied were 89 kg N/ha, 79 kg P_2O_5/ha and 63 kg K_2O/ha for the treatment with liquid manure once the recommendation of N for the crops, and the double for the treatment two times the recommended N for the crops.

The total amounts of applied nutrients were of kg N/ha, 79 kg P_2O_5/haand 63 kg K_2O/ha for the treatment with liquid at the recommended rate of N of the crops and the double for the treatment two times the recommended rate. 10.7 Mg/ha of swine bedding on 01/10/2007 was applied at once (1x) the recommended N and 21.4 Mg/ha for double the recommendation. The total quantities of N, P_2O_5 and K_2O represented in the bedding were, respectively 90, 88.6 and 74 kg/ha for the recommendation of one dose of N and 180, 177.2 and 148 kg/ha for the double the recommendation. The levels of N- NO_3^- were evaluated in four soil layers (0-15, 15-30, 30-45 and 45-60 cm) at 0, 7, 35, 53, 73 and 142 days after the application of the bedding and the first application of liquid swine manure and urea. For each plot, 6 sub-samples of soil were taken, with help of a Dutch auger, to form a composite sample. The material was transported to a laboratory, dried and then sieved, thus obtaining the fine air dried soil (TFSA). A sub-sample for extraction with KCl 1 mol/L and determination of N- NO_3^- by distillation with semi-micro Kjeldahl equipment (Tedesco *et al.* 1995). The results for each soil layer for the different sampling dates were submitted to analysis of variance and treatment means were compared by the Tukey test at 5% significance level.

Results

The analysis of variance found that the application of swine manure promoted significant modifications in the levels of N- NO_3^- in the soil, in depth and for the different sampling dates. The levels of N- NO_3^- at 7 days after the application were higher in the treatments DL2x for the surface layer (Figure 1). At 35 days there were increases at the depth of 30-45 cm, which reinforces the hypothesis of rapid nitrification of the liquid swine manure, as the demand of maize was small. This result may be related to the fast infiltration of NO_3^-in soil where urea is hydrolyzed and the ammonium is quickly converted to nitrate, resulting in the increase of its concentration (Costa 2001). The N losses by leaching occur mainly in the early stages of crop establishment, when the root system is not yet sufficiently developed in relation to the rapid nitrification of ammoniac nitrogen from the swine manure in the soil and the low adsorption of N- NO_3^-The rate of mineralization of the waste is extremely important for nutrient availability to plants and may vary depending on the type of manure, the attributes of soil, moisture and humidity.

At 73 days after the first application of pig slurry it was observed that a higher level of the NO_3^- in the treatment DL2x in the 45 to 60 cm layer, thus confirming the occurrence of leaching, that leads to an increased risk of groundwater contamination. At day 142 toward the end of the culture cycle, there were lower levels of nitrate in the surface layer and high levels in the 45-60 cm layer, mainly for the treatment DL2x, this demonstrates that the applied values nitrogen was higher than that assimilated by the crop, even under split applications of liquid manure. Another important factor for the increase at depth of nitrate, may have been due to the high rainfall observed in this period, which probably favoured the leaching of NO_3^-. Aita and Giacomini (2008) found in RS that with the application of 0, 40 and 80 m^3/ha of pig manure a rapid increase in leaching of NO_3^- occurs, especially with the highest dose of manure.

The lowest value of N- NO_3^- was for swine bedding litter relative to the slurry, at 142 days at 60 cm depth. This can be due to slower leaching related to the bedding staying on the surface. In studies of fertilization with slurry and swine bedding litter in a Paleudalf in Rio Grande do Sul, Giacomini and Aita (2008) found a temporal variation of the quantities of N- NO_3^- in the soil to the depth of 90 cm. The slurry caused a higher amount of N- NO_3^- in the soil relative to treatments with litter. Oliveira (1993) observed that in soils submitted to applications of high levels of liquid swine manure for several years (160 m^3/ha), the level of NO_3^- in groundwater was ten times higher than found in untreated soils.

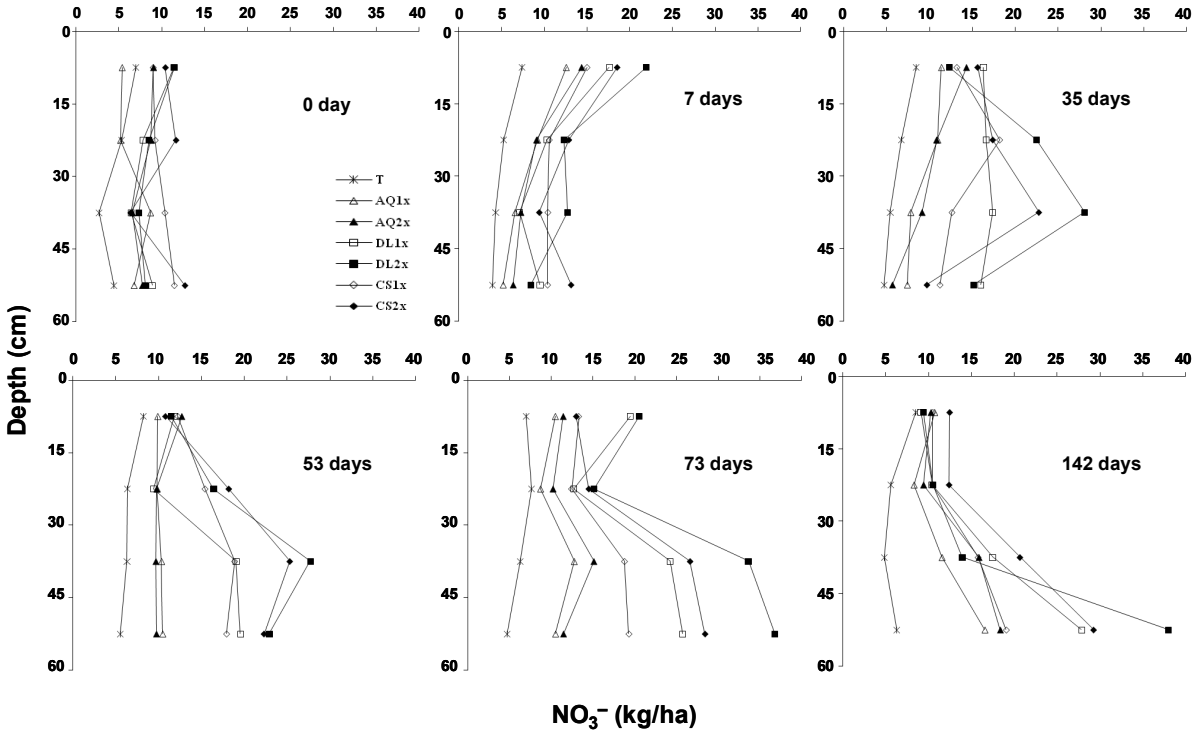

Figure 1. Levels of N- NO_3^- in soil layers to 0-60 cm during the culture of maize.

Conclusion

In general, increases in levels of nitrate had occurred in soil, receiving swine manure, but they were not considered critical to the environment. The doubled fertilization with liquid swine manure has more nitrogen than is assimilated by the crop and over time may present risk of leaching of NO_3^-. The highest concentrations were observed in the 60 cm soil at the end of the crop cycle. Criteria should be developed for dosages, range of application of manure and the adoption of SPD to minimize environmental impact due to losses of nitrate by leaching.

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