Dynamics of C/N and nutrients in Oxisol soils treated with swine digestate

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Introduction

It is well known that intensive swine production can be harmful to the environment in many ways. Firstly, it is necessary to allocate large areas to produce exclusively grain (soya/corn) as feed resources, without considering the provision of ecosystem services like more diversified agroecosystems (Power, 2010). Secondly, groundwater is usually employed at a high rate of 10L per swine (Bergier et al., 2012). Lastly, livestock industrialized wastes (basically manure, urine, hair and feed), if improperly disposed, can hazard the air (ammonia and methane emissions), water (ponds, streams and groundwater) and the pristine and cultivated soils (Buller, 2016). To tackle some of these issues, entrepreneurs in São Gabriel do Oeste (MS, Brazil) have developed a set of technologies grounded on waste biodigestion (Bergier et al., 2013). Diesel adapted machines are now able to convert calorific power of biogas into useful energy at 40% efficiency. Those biogas-driven machines have been successfully employed to distribute swine digestate (effluent) in soils, particularly under pasture for cattle. We present C/N and nutrient soil data of 6 integrated swine-cattle farms in São Gabriel do Oeste that have been applying effluent to pasture over different time spans and variable effluent doses. The results are discussed under the light of effluent application, soil depth and time spans of effluent application.

Material and Methods

Samples of soil were gathered at different depths with a soil sampler between 22/12/2009 and 10/05/2012 in Oxisol soils under pasture of swine-cattle farms in São Gabriel do Oeste. The spanning time of effluent application was the basic criterion to select sampled farms. Soils assumed free of effluent in farms were also sampled as testimony. At the laboratory of Embrapa Pantanal, soil samples followed standard procedures for measuring carbon (C) and nitrogen (N) in a CHNS Elementar, and phosphorous (P), cooper (Cu) and zinc (Zn) in an Atomic Absorption Perkin Elmer 3300.

Results and Conclusions

Figure 1 shows the results in four plots. The plots 1A, 1B and 1C compare C/N with Cu, Zn and P concentrations. The y-axis of these graphs in log-scale is divided at concentration ~ 3.3 mg/kg while the x-axis is divided at C/N ~ 15.3 (means testimony bulk soil values). Data shows that soils treated with effluent between 5-30 cm depth and spanning 6 years present C/N $<<$15.3 and nutrient concentration $>>$3.3 mg/kg. The plot 1D evidences that the farm spanning 6 years of effluent application largely reduce its soil C/N in comparison to soil testimony likely due to priming effect (Fernandes et al., 2011). However, the results indicate that swine digestate can be applied to Oxisol soils to improve its fertility without compromising C/N, particularly at deeper soil layers. The results reinforce that instead of application time span, the application dose is the main variable to be considered as the soil nutrients stock is a balance between effluent input and plant absorption/extraction. As a result, dosage must be carefully amended to avoid C/N reduction and soil saturation with Cu, Zn and P (and other elements e.g. Na, Mg, etc.), as identified to the farm spanning 6 years of effluent application likely with high dosage rates.

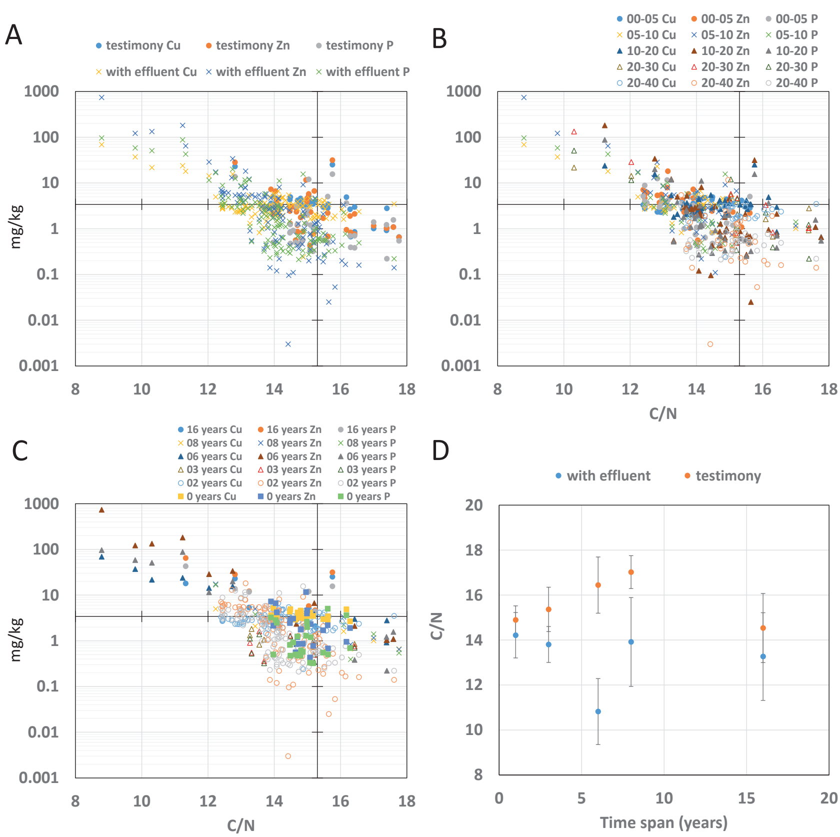

Figure 1. Relationship between C/N with Cu, Zn and P concentrations in soils extracts accordingly to effluent application or not (testimony) (A), soil depth (B), time span of effluent application (C). The origin of the plots A, B and C is defined as the mean C/N and concentration values of testimony soils. The mean C/N (±1SD) against effluent time span is also shown for bulk soils (all depths) with and without (testimony) effluent application (D).

Bergier et al. (2012) have defined an ‘acceptable’ dosage rate of ~1 hectare of pasture for each 100 swine. Pasture soils treated with digestate can then be well managed to improve C/N ratio over time in the same way as cultivated pasture with mineral NPK (Bergier et al., 2012). By respecting the critical dosage rate, the risk of soil nutrient saturation and C/N depletion can be minimized. State government policy of swine-cattle integration must therefore consider adequate dosages for licensing swine intensive production in Oxisol soils. Government supervision should consider e.g. 4-year monitoring of top soil samples at 0-10 cm depth and the thresholds C/N < 12 and Cu, Zn and P > 10 mg/kg as a decision support to revoke environmental licenses to keep a better level of sustainability in swine production.

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