Gaseous fluxes in Oxisol soil surfaces at integrated plant-livestock systems

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Introduction

Greenhouse gas emissions from agriculture, forestry and other land use together are responsible for 10-12 $GtCO_2$-eq/year, which correspond to 24% of anthropogenic global emissions by sector (IPCC, 2014). In agriculture, the most cost-effective mitigation options are cropland management, grazing land management, and restoration of organic soils. This work contributes with information concerning soil gaseous emissions from a managed farm system in the Campanário Settlement at São Gabriel do Oeste (MS). The food production system comprises the integration of swine-forestry-soya/corn (cattle was expected but not effectively implemented) regularly fertilized with standard NPK. The experiment consisted of additionally applying swine effluent of biodigester as an organic fertilizer with known doses (measured, not shown) in sites with arrangements of forestry mixed with agriculture (soya/corn rotation).

Material and Methods

The site description is available elsewhere e.g. Buller et al. (2015). In fieldwork, it was obtained a total of 1105 chamber flux measurements distributed in 36 sites between 26/Sep/2013 and 4/Jun/2014 mostly in the morning (Figures 1 and 2).

Fig 1. Chamber flux measurements at the soil-air interface in integrated livestock-plant system.

The measurements were made on site with a plexiglass closed chamber connected by tubing to a Lumasense Innova 1412 photoacoustic systems with optical filters for measuring carbon dioxide (CO_2), nitrous oxide (N_2O), ammonia (NH_3), Sulfur dioxide (SO_2), and methane (CH_4). It was possible to recalibrate CO_2, N_2O and CH_4 with a GC/SRI-FID/ECD and a Los Gatos Inc. UGGA. Unrecalibrated SO_2 and NH_3 data is presented for insightful interrelationships. Data in Figure 2 represent for each gas species (g) the site-specific medians (med_{sg}) normalized (med_{ng}) by the all sites medians (med_{ag}) and interquartile ranges (ir_{ag}) as $med_{ng} = (med_{sg} - med_{ag})/ir_{ag}$. Figure 3 shows interrelationships among median fluxes per site (n = 36 median values).

Results and Conclusions

In general, gaseous fluxes showed large variability likely due to local and temporal effects (Figure 2).

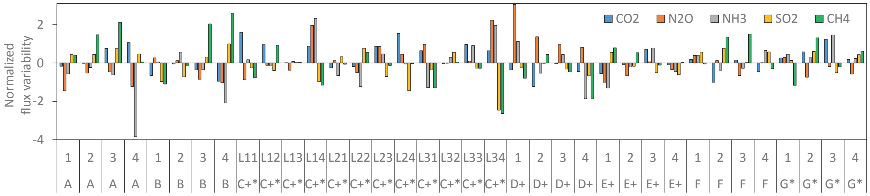

Figure 2. Variability of normalized gas fluxes. Numbers in the x-axis are site replicates, (+) denotes sites that received digested swine effluent, and (*) sites with eucalyptus planted in 2011.

CO_2 fluxes ranged from 7,760 to 10,376 mg/m^2/d, N_2O fluxes ranged from -1.33 to 7.66 mg/m^2/d, and CH_4 fluxes ranged from -0.41 to 0.15 mg/m^2/d. Figure 2 presents normalized flux variability in spatial terms. CO_2 fluxes were higher than overall median particularly in forested sites (C and G), independently of effluent application (Kruskall Wallis test p = 0.010, n = 36).

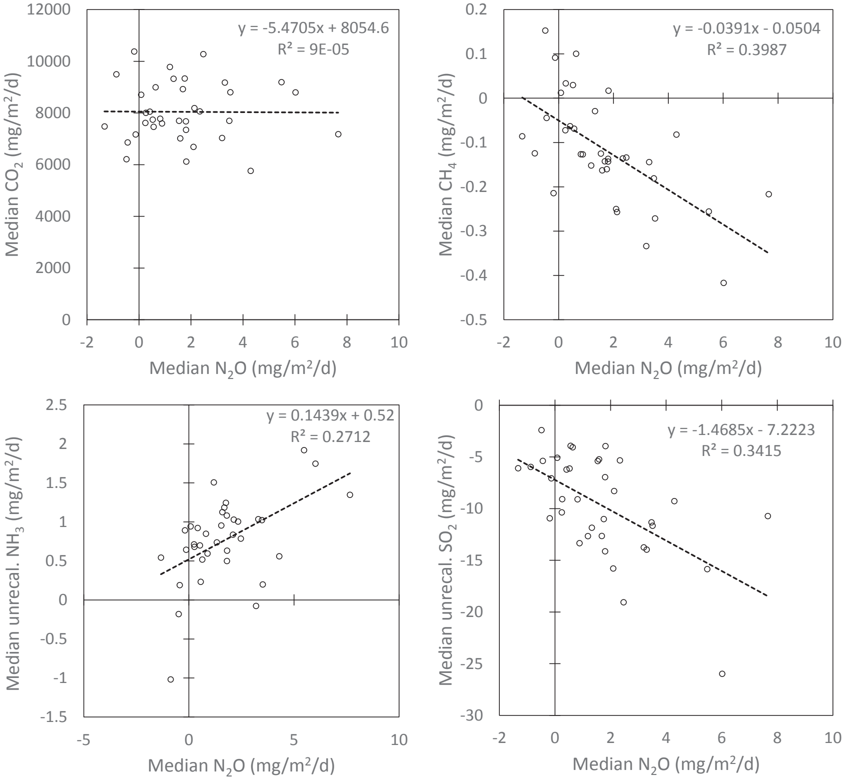

Figure 3. Interrelationships of median N_2O fluxes with median CO_2, NH_3-unrecalibrated, SO_2- unrecalibrated, and CH_4 fluxes.

Unsurprisingly, N_2O fluxes were higher than overall median particularly in sites that received swine effluent (Kruskall Wallis test p = 0.012, n = 36). NH_3, SO_2 and CH_4 fluxes were not significantly different between sites (Kruskall Wallis test p = 0.285, 0.104, 0.167, respectively).

In Figure 3, it is possible to state that:

CO_2 fluxes do not correlate with N_2O fluxes because CO_2 derives from soil and biomass (maize and soya plants left in the ground) respiration independently of N additions;

N_2O and NH_3 fluxes are positively correlated ($p = 0.001$, $AIC = 137.732$) probably due to an excess of ammonia from fertilizers (NPK and swine effluent) which leads to N_2O formation through nitrification and/or denitrification;

N_2O and SO_2 fluxes are inversely correlated ($p = 0.000$, $AIC = 141.217$) as SO_2 sink can stimulate NO and N_2O emissions in acidic soils in which nitrification dominates NO and N_2O production (Cai et al., 2012); and

N_2O and CH_4 fluxes are inversely correlated ($p = 0.000$, $AIC = 137.629$) likely associated to N-stimulation of soil methanotrophic bacteria.

References

BULLER LS, BERGIER I, ORTEGA E, MORAES A, BAYMA-SILVA G, ZANETTI MR.

Soil improvement and mitigation of greenhouse gas emissions for integrated crop–livestock systems: Case study assessment in the Pantanal savanna highland, Brazil. Agricultural Systems, 137: 206-219, 2015. doi: 10.1016/j.agsy.2014.11.004

CAI Z, ZHANG J, ZHU, T, CHENG Y. Stimulation of NO and N_2O emissions from soils by SO_2 deposition. Global Change Biology, 18(7): 1365-2486, 2012

IPCC (INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE). Summary for Policymakers. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. 2014. < https://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_summary-for-policymakers.pdf >.

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