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Interactive comment on “N_2O and N_2 losses from simulated injection of biogas digestate depend mainly on soil texture, moisture and temperature” *by* Sebastian Rainer Fiedler et al.

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The following phrases, sentences and passages were omitted to shorten the manuscript according to referee no. 3 upon consultation with the editor. Line numbers refer to the revised manuscript uploaded on July 4th 2017.

L 2 – 3: "depend mainly on soil texture and moisture”

L 34 – 35: “Further, emission of ammonia (NH3) is of environmental concern, e.g., due to acid deposition or conversion to N2O (Ferm, 1998; Mosier et al., 1998).

L 38 – 39: “In Germany, the increased demand for renewable energy sources like methane entails an expanded amount of”

L 42: like animal slurry

L 44 – 45: “In general, the effect strengths of BD on gaseous N losses from soil is still under debate (Möller, 2015).

L 57 – 58: “like the favoured reduction of NO3- rather than N2O as alternative electron acceptor”

L 60 – 63: “Diffusion of O2 depends on the porosity of the soil substrate in conjunction with water-filled pore space (WFPS), while O2 is consumed by heterotrophic respiration which depends on mineral N content, carbon (C) availability as well as on temperature.”

L 66 – 71: “Simultaneously, the supply of substrates for microorganisms is determined by liquid diffusion rates in soil water and, thus, by WFPS (Blagodatsky and 4 Smith, 2012; Maag and Vinther, 1999). However, though high within injection bands, nutrient concentrations and WFPS should theoretically increase further with the row spacing between the injection bands, if a given amount of BD per area is assumed. We are not aware of studies addressing the effect of such high BD concentrations.”

L 74 – 78: “The indicated knowledge gaps are caused not the least by methodological constrains with the direct determination of N2 fluxes due to the high background level of N2 in the atmosphere, while indirect applications like acetylene-based methods and 15N tracers are unfavourable since the former implicates serious underestimations and the latter has rather high detection limits (Groffman et al., 2006).”

L 114 – 117: “The mixing was done for methodical reasons since the available space in the incubation vessels was limited and, hence, ‘real’ injection not feasible. However, injection bands have actually a thickness comparable to the sample rings we used.”

L 193 – 202: “After incubation, the recovered NH4+-N contents increased with the level of amendment with BD in both soils and were not affected by WFPS, with the exception of treatments of clayey silt with 35% WFPS (Fig. 2). In the loamy sand, the

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mean amounts of NH4+-N per kg soil ranged from 8.5 to 10.0 mg (no amendment), from 170.4 to 185.6 mg (LOBD) and from 273.7 to 314.0 mg (HIBD). In the clayey silt, NH4+-N contents per kg soil reached only 1.8 to 8.8 mg (no amendment), 89.7 to 98.9 mg (LOBD) and 146.8 to 194.0 mg 198 (HIBD) and, thus, roughly half the amounts of the clayey silt. However, in contrast to the loamy sand, the clayey silt showed also substantial NO3- contents between 25.7 (35% WFPS without amendment) and 49.8 mg NO3–N (kg soil)-1 (55% WFPS with LOBD). Negligible amounts of NO3- were detected in the loamy sand after incubation: except for a mean value of 2.4 mg NO3–N (kg soil)-1 in the unamended treatment with 75% WFPS, the values of all other treatments ranged between 0.2 and 0.5 mg."

L 204 – 209: "While mean values from 38.6 (55 % WFPS without amendment) to 500.1 mg DOC per kg soil (75 % WFPS, HIBD) were determined for the loamy sand after incubation, lower mean values from 18.9 (55 % WFPS without amendment) to 358.1 mg (35 % WFPS, HIBD) were found in the clayey silt, where the respective second highest values were considerably lower for both soils (loamy sand: 362.2 mg for 75 % WFPS with 208 LOBD, clayey silt: 105.9 mg for 75 %WFPS with HIBD)."

L 212 – 212: "from 8.3 to 57.6 (aerobic atmosphere at 2°C), from 34.0 to 168.7 (aerobic at 15 °C) and from 11.2 to 87.9 mg CO2-C m-2 h-1 213 (anaerobic at 15°C)"

L 214 – 215: "Although the mean fluxes from the clayey silt were also always smallest in the unamended treatments,

L 222 – 229: "This was similar at 15°C with the exception of 35% WFPS without digestate (0.1 mg N2O-N m-2 h-1 , Fig. 3, Day 4 in Table A2). The clayey silt showed much larger fluxes than the loamy sand: even at 2 °C, up to 1.5 mg N2O-N m-2 h-1 were detected (55% WFPS with LOBD). After shifting the temperature to 15 °C, the same factor combination had a mean flux of 6.2 mg N2O-N m-2 h-1 and the other treatments emitted in mean between 1.0 and 3.0 mg N2O-N m-2 h-1 with the exception of incubations with 35% WFPS, where fluxes were smaller. The sand showed weak N2O emissions, independent of temperature and WFPS as well as the amount of BD application. In contrast, the emissions of the clayey silt increased with temperature and were highest with intermediate WFPS and amount of BD, i.e. 55% and LOBD, respectively"

L 232 – 233: "However, this effect was not noticed at 35% WFPS due to generally low emissions at this moisture level."

L 245 – 247: "After increasing the temperature to 15 °C, again, the sandy loam released mostly negligible rates of N2, except for 0.5 mg m-2 h-1 with 55% WFPS and 320 kg N ha-1 246 (Fig. 4, Day 4 in Table A3)."

L 256 – 257: "from 3.3 (35% WFPS without N)"

L 258: "were always higher than fluxes from the unamended ones"

L 260 – 261: "not reaching the amounts observed for the sandy loam. This implies that the N2 emissions were increased from both soils under anaerobic headspace conditions"

L 320 – 328: "An increasing application of BD tended also to decrease the N2/(N2+N2O) ratio, but this effect was also not significant (p > 0.05, Tuckey's HSD). In general, nitrite (NO2-) and NO3- are preferably reduced compared to N2O during denitrification sequence since the energy yield of each reduction step decreases from NO3- to N2O and the reaction rate of reduction is higher for NO3- and NO2- than for N2O (Betlach and Tiedje, 1981; Koike and Hattori, 1975). Hence, increasing application rates of BD increase the availability NO2- and NO3- from NH4+ oxidation which, consequently, decreases N2O reduction. However, in field situations, sooner or later an important fraction of this NH4+ will be nitrified and can lead to further N2O and N2 emissions if the WFPS is at sufficient levels. The inhibitory effect is in line with the strong influence of NO3- content of the soils after incubation (Table 5)."

L 339 – 340: "Notably, in contrast to the clayey silt, no or negligible concentrations of NO3- were found in all treatments with loamy sand."

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L 342 – 344: “Actually, high NH4+ loads in conjunction with alkaline conditions are typical for BD (Möller and Müller, 2012), which favour NO2- accumulation and may be the reason for the relatively small NO3- recovery in both soils (van Cleemput and Samater, 1995).”

L 366 – 368: “However, the large production rates indicate that also the loamy sand harboured the necessary microbial community able to generate N2 as soon as the atmospheric conditions become favourable.”

L 377 – 379: “Alternatively, the much smaller increase of N2 fluxes from the clayey silt could have resulted from depleted mineral N stocks (NO3- and NH4+) due to the previous gaseous N losses during the course of incubation”

L 390 – 393: “Similarly to N2O and N2 generation by denitrification, respiration depends on the microbial availability of carbon as well. Although anaerobic digestion reduces readily degradable organic matter in BD, a ‘labile’ fraction usually remains, but the biodegradability of the respective residual organic carbon is variable, depending on the origin of BD (Askri et al., 2015).”

L 396 – 397: “both in the not amended and especially in the amended treatments.”

L 407 – 409: “Although CO2 fluxes were mostly higher in the treatments with 320 kg compared to LOBD, this behaviour was not generally reflected in the separate emissions of N2O and N2 which might be a result of the”

L 410 – 413: “However, the N2/(N2O+N2) ratios implied a tendency of N2O reduction due to a shortage of alternative electron acceptors like O2 in the highly amended treatments. Additionally, increasing temperature also influenced indirectly the aerobic status of the soils due to increased microbial activity and, hence, respiration.”

L 414 – 423: “No indications for BD induced short-term priming effect We further checked for a short-term priming effect after amendment with BD as suggested recently by Coban et al. (2015). After balancing cumulated net CO2-C-fluxes (difference between amended and unamended treatments) against the calculated DOC-C application with BD for the period of aerobic headspace, we found no evidence for a short-term priming effect. In the loamy sand with LOBD, between 76% (35% WFPS) and 103% (75% WFPS) of the DOC-C had been respired (data not shown). In the respective treatments with 320 kg N ha-1, the CO2-C losses ranged from 47% (35% WFPS) to 76% (75% WFPS). By contrast, only between 11% (320 kg N ha-1) and 42% (LOBD) has been respired in the clayey silt (both at 55% WFPS). However, if one would consider the period after BD application for a longer time than we would, the light loamy sand may be vulnerable for C losses after BD application than the cloggy clayey silt."

L 426 – 427: "since we have data for at most two days of static conditions in terms of temperature and headspace aerobicity."

L 428 – 433: "Generally, the initial phase, i.e., the first week after fertilizer application, is crucial for N2O emissions (Dobbie et al., 1999) and most probably also for N2 because the same processes are involved. Köster et al. (2011; 2015) and Senbayram et al. (2009) observed in incubation experiments N2O peaks within the first and third day, which indicate a rather immediate reaction also for N2 at least in vitro. Nevertheless, the former studies recorded a second plateau of N2O emission consistently after around two weeks, though, at very high WFPS."

L 436 – 456: "Moreover, on the one hand, we observed no changes of N2O in the clayey silt under anaerobic headspace, which suggest no further increase would have awaited if we had extended the incubation period with aerobic headspace. The increased N2 emissions on the last day showed the potential, which would have arisen if the soil cores had been completely anaerobic. The latter has, however, no implications for mineral soils since such conditions are unlikely to occur in situ. On the other hand, the extremely increased N2 emissions from the loamy sand on the last day verify that this soil permitted abundantly oxygen diffusion, which let us assume no appearances of possible second emission increases in the former aerobic headspace. [. . .] microbes associated with the production of N2O and N2 in soils are able to react fast to chang-

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ing environmental conditions by utilising existing enzymes within minutes or by de novo synthesis within 4 – 8 hours (Rudaz et al., 1991)."

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