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Gaseous Emissions after Soil Application of Pellet Made from Composted Pig Slurry Solid Fraction: Effect of Application Method and Pellet Diameter

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Abstract: The study aimed at determining ammonia and GHG emissions from soil fertilized with pellets made from composted pig slurry solid fraction and to evaluate the effects of pellet diameter and pellet application method on gaseous emissions. A laboratory scale experiment was carried out investigating two composts: pig slurry solid fraction compost (SSFC) and pig slurry solid fraction mixed with wood chips compost (WCC). The two composts were pelettized in two different diameters—6 and 8 mm—by means of mechanical pelletizer. In total, eight fertilized treatments plus one unfertilized control were included in the experiment. The investigated pellets were applied at the same nitrogen rate (equivalent to 200 kg ha^{-1}) using two different methods (on soil surface and incorporated into the soil). Ammonia (NH_3) emission was monitored immediately after pellet application, while nitrous oxide (N_2O), carbon dioxide (CO_2) and methane (CH_4) were measured on a 57-day incubation period. As expected, ammonia volatilization was not detected from any of the treatments investigated. At the end of the experiment, the cumulative amounts of N_2O, CO_2 and CH_4 ranged from 2.70 mg N-N_2O m^{-2} to 24.30 mg N-N_2O m^{-2}, from 601.89 mg C-CO_2 m^{-2} to 1170.34 mg C-CO_2 m^{-2} and from 1.22 mg C-CH_4 m^{-2} to 1.31 mg C-CH_4 m^{-2}, respectively. The overall results of the investigation highlighted that application on the soil surface reduced nitrous oxide emission, while the carbon dioxide emission increased significantly with smaller pellet diameter.

Keywords: pelletizing; composting; pig manure; GHG; ammonia

1. Introduction

All over the world, intensive pig breeding and increased size of livestock farms have resulted in the production of huge quantities of liquid pig manure (slurry) in specific geographic areas such as the Yangtze River in China; Iowa, Minnesota and North Carolina in the United States; Denmark, Belgium, Spain, Germany and Italy in the European Union and the Southern states of Brazil [1–4]. According to the last Italian National Census of Agriculture (2010), in Italy, about 90% of the national pig asset is concentrated in three regions in the north part of the county—Piedmont, Lombardy and Emilia-Romagna [5]—producing approximately 17 million tons of pig slurry per year [6].

In these areas, pig slurry is generally inefficiently recycled due to the slurry management adopted by livestock farmers which mainly consists in land spreading after pond storage [7]. The excessive amount of pig slurry spread on agricultural land lead to several environmental pollution risks such as nitrate (NO_3^-) leaching into groundwater, phosphorous (P) runoff into surface waters and ammonia (NH_3) and green-house gas (GHG)—methane (CH_4), nitrous oxide (N_2O) and carbon dioxide

(CO_2)—emissions into the atmosphere [8–10]. In this context, the Intergovernmental Panel on Climate Change (IPCC) [11] estimates that agricultural activities, including land application of animal manure, account of about 20% of the total human induced global warming budget due to GHG emissions.

To minimize the risk of environmental pollution, several technologies have been developed to better manage pig slurry. In this context, the separation of pig slurry into two phases—liquid (LF) and solid (SF)—simplifies slurry management by reducing its volume. The liquid fraction, rich in soluble nitrogen [12], is typically applied to agricultural lands near the production site, while the solid fraction, characterized by greater amount of nutrients (nitrogen and phosphorous), organic matter (OM) and dry matter (DM) [12], can be moved and distributed on lands at greater distance from the livestock farm.

According to Pampuro et al., pelletizing pig slurry SF could improve its benefits by increasing the bulk density of SF from an initial value of 400–450 kg·m^{-3} to a final one of more than 1000 kg·m^{-3} and, consequently, reducing transport, handling and storage costs [13–16]. Moreover, the studies conducted by Alemi et al. [17] and Romano et al. [18] highlighted that pelletizing promote the concentration of the nutrients available in the SF improving its fertilizing and amending properties. This process has also the potential for creating a new market for pelletized pig slurry SF, when the properties of this material and the benefits related to biological fertility and biodiversity of soils will be better known among potential users [19].

However, pelletizing of fresh pig slurry SF is strongly limited by its high moisture content, which typically ranges from 75% to 80%. These values are higher than the range of values (20–40%) indicated by Alemi et al. as the optimal condition for SF densification. According to Pampuro et al. [20,21], as a consequence of the heat generated by the aerobic stabilization, which promotes water evaporation, turning windrow composting represents a cheap and simple solution to allow SF pelletizing. Moreover, the addition of carbon rich lingo-cellulosic bulking agents, such as wood chips, to the SF optimizes the substrate properties, such as carbon to nitrogen ratio (C/N) and air spaces, positively affecting the composting process [22].

Although many studies [9,23–25] to assess gaseous losses after soil application of raw slurry, SF or composted manure have been carried out, there are not any results from studies on ammonia and GHG emissions generated after soil application of pellet made from composted pig SF. With the aim to cover this knowledge gap, a laboratory scale experiment was carried out in order to: (i) determine ammonia and GHG emissions from soil fertilized with pellet made from composted pig SF (applied at equivalent nitrogen rate); (ii) evaluate the effects of pellet diameter and pellet application method on NH_3, CH_4, N_2O and CO_2 emissions.

2. Materials and Methods

2.1. Treatments and Experiment Setup

The experiment was carried out using two different composts: pig solid fraction compost (SSFC) and wood chips compost (WCC) obtained by mixing 8000 kg of pig solid fraction with 2400 kg of wood chips derived from park maintenance. The procedures for obtaining SSFC and WCC were fully described in a previous study conducted by Pampuro et al. [26].

Pelletizing of the composted materials was carried out by means of mechanical pelletizer CLM200E (La Meccanica Srl, Padua, Italy). The two composts were pelettized in two different diameters: 6 and 8 mm.

The obtained pellets were analysed for pH, moisture content, dry matter content (DM), total organic carbon (TOC), total nitrogen (TN), ammonium nitrogen (NH_4^+-N), nitric nitrogen (NO_3^--N), organic matter (OM), cation exchange capacity (CEC), total phosphorous (expressed as P_2O_5) and total potassium (expressed as K_2O), and carbon to nitrogen ratio (C/N) calculated. A Hanna HI portable pH meter fitted with a glass electrode combined with a thermal automatic compensation system was used to determine the pH. Pellet moisture content was measured after drying at 105 °C for 12 h and

OM content by loss on ignition at 430 °C for 24 h [27]. TOC analysis were performed by means of C analyzer (Carlo Erba Instruments, Rodano, Milan, Italy) after drying the pellet at 105 °C for 24 h, followed by treatment with sulphuric acid (H_2SO_4). Kjeldahl standard method was used to determine total and ammonium nitrogen [28] while ion chromatography (Dionex-4000i, Dionex, Sunnyvale, CA, USA) was used to determine nitric nitrogen. Sodium chloride adsorption followed by the potassium nitrate displacement method was used to measure CEC [29]. P_2O_5 was analysed by colourimetry and K_2O by flame photometry after $HNO_3/HClO_4$ digestion [30]. The main chemical properties of the investigated pellets are reported in Table 1.

Table 1. Chemical characterization of the two pellet types investigated (SSFC: slurry solid fraction compost, WCC: Woodchip compost). Mean value and standard error (S.E.) of 3 replicates.

Parameter	SSFC (Ø 6 mm and Ø 8 mm)		WCC (Ø 6 mm and Ø 8 mm)	
	Average	S.E.	Average	S.E.
Dry Matter (%)	85.4	0.7	84.6	0.4
Moisture (%)	14.6	0.7	15.4	0.4
pH	8.1	0.1	7.9	0.1
TN (%)	3.3	0.1	2.9	0.1
NH_4^+-N ($mg \cdot kg^{-1}$)	672.0	10.5	495.8	17.7
NO_3^--N ($mg \cdot kg^{-1}$)	1460.0	13.8	2390.0	13.8
TOC (%)	36.9	0.4	38.1	0.2
C/N	11.2	0.3	13.2	0.3
OM (%)	63.6	1.5	65.7	0.5
CEC ($cmol \cdot kg^{-1}$)	70.9	1.7	79.5	4.2
P_2O_5 (%)	4.0	0.1	3.7	0.2
K_2O (%)	1.0	0.1	1.6	0.1

TN, total nitrogen; NH_4^+-N, ammonium nitrogen; NO_3^--N, nitric nitrogen; TOC, total organic carbon; C/N, carbon to nitrogen ratio; OM, organic matter; CEC, cation exchange capacity; P_2O_5, total phosphorous; K_2O, total potassium.

The experiment was set up in a randomized block design with four replicates. Nine treatments were investigated: (1) SSFC Ø 6 mm on soil surface applied [SSFC 6 SUP]; (2) SSFC Ø 8 mm on soil surface applied [SSFC 8 SUP]; (3) SSFC Ø 6 mm incorporated into the soil [SSFC 6 MIX]; (4) SSFC Ø 8 mm incorporated into the soil [SSFC 8 MIX]; (5) WCC Ø 6 mm on soil surface applied [WCC 6 SUP]; (6) WCC Ø 8 mm on soil surface applied [WCC 8 SUP]; (7) WCC Ø 6 mm incorporated into the soil [WCC 6 MIX]; (8) WCC Ø 8 mm incorporated into the soil [WCC 8 MIX]; (9) Control without pellet [CON].

An agricultural clay-silty soil was used in the experiment. Soil was air dried, mixed and sieved (<5 mm) before analysis and incubations. Basic chemical properties of the soil are reported in Table 2.

The experiment was carried out in glass jars (3.2 L capacity) intended to mimic the plough layer (0–30 cm) of the soil. According to Subedi et al. [31], all the jars were filled with 1.5 kg of dry soil and moistened with deionized water in order to reach 60% of water filled pore space (WFPS). The soil was then brought back to field density ($1.35\ g \cdot cm^{-3}$) [32] at which the headspace volume equaled $2000\ cm^{-3}$. Next, the jars were pre-incubated at 20 °C until the initial CO_2 flux, due to soil rewetting, had subsided (10 days).

The jars were then manually fertilized with the investigated pellet at rate of 20 g of $N \cdot m^{-2}$, corresponding to $200\ kg \cdot N \cdot ha^{-1}$. The amount of nutrients supplied to the soil with the different pellet was 240 kg P_2O_5 ha^{-1} and 60 kg K_2O ha^{-1} and 255 kg P_2O_5 ha^{-1} and 110 kg K_2O ha^{-1} for SSFC and WCC, respectively.

As stated by Bateman and Baggs [33], the jars were placed in a climatic room at a constant 25 °C and air humidity of about 55% in order to guarantee the optimal conditions for N mineralization and N emissions. The soil moisture content was maintained constant (60% of WFPS) during the 57-day period, gravimetrically adjusted every 2–3 days for each individual jar, at least 12 h before a gas measurement.

Table 2. Basic chemical properties of the soil used in the experiment. Mean value and standard error (S.E.) of 3 replicates.

Parameter	Average	S.E.
pH	8.55	0.01
EC (dS m^{-1})	0.18	<0.01
WHC (%)	31.50	1.02
$CaCO_3$ (%)	38.70	0.40
CEC (cmol·kg^{-1})	10.50	0.50
OM (%)	0.88	0.03
TOC (%)	0.51	0.01
TN (%)	<0.01	<0.01
C/N	7.29	0.09
NH_4^+-N (mg·kg^{-1})	10.80	0.80
Available-P (mg·kg^{-1})	27.70	0.50

EC, electrical conductivity; WHC, water holding capacity; $CaCO_3$, calcium carbonate; CEC, cation exchange capacity; OM, organic matter; TOC, total organic carbon; TN, total nitrogen; C/N, NH_4^+-N, ammonium nitrogen; P, phosphorus.

2.2. Gaseous Emissions Measurements

Ammonia emissions were measured immediately after pellets application by means of a dynamic chamber system coupled with a photo-acoustic trace gas analyzer (PTGA) (INNOVA 1412, LumaSense Tech, Santa Clara, CA, USA). NH_3 emissions at 20 °C and air flow rate of 2 L·min^{-1} were measured for 48 h [31]. The NH_3 emitted in volatilisation chamber (i.e., head space of each jar) was sampled from an expansion bottle (1 L capacity) and analyzed with PTGA connected with the volatilization system.

CO_2, CH_4 and N_2O emissions from the jars were measured three times a week for the first 2 weeks, then twice a week for the following 3 weeks and once a week for the last 4 weeks for a total of 16 times during the 57-day period. GHG flux measurements were conducted with each jar sealed with a gas-tight polyethylene lid equipped with two Teflon tubes (each 50 mm long) punctured by several small holes (0.5 mm diameter) sampling air from the whole headspace height. Thirty mL of air was drawn with a plastic syringe from the jar headspace at 0, 9 and 18 min after jar closure. All samples were stored in airtight glass vials and analyzed for CO_2, CH_4 and N_2O within 24 h by gas chromatography (Agilent 7890). The gas chromatograph (GC) was equipped with a thermal conductivity (TCD), a flame ionization (FID) and an electron capture (ECD) detectors for determination of CO_2, CH_4 and N_2O concentrations, respectively. Helium (He) and a gas mixture of argon and methane (Ar–CH_4) were used as the carrier gas for CO_2/CH_4 and N_2O, respectively. The concentrations of each GHG (CO_2, CH_4 and N_2O) were plotted over time, the data were then fitted to a 1st degree equation ($C = ax + b$; were C is the concentration of gas and x represents time in minutes) or 2nd degree polynomial equation ($C = ax^2 + bx + c$), the slop of which gave the relative change in concentrations per chamber volume and minute. Gas fluxes F in mg m^{-2} min^{-1} were determined according to:

$$F = (dC_{gas}/dt) \times (V/A) \quad (1)$$

where: dC_{gas}/dt is the change of CO_2, CH_4 or N_2O concentration in the jar headspace in mg·min^{-1}; V is the chamber volume in m^3 and A is the area of the jar headspace in m^2. Cumulative emissions were approximated by assuming that daily fluxes represented the average flux between each measurement.

Total gaseous losses were expressed in carbon dioxide equivalent (CO_2-eq) using conversion factors of 1, 28, 265 and 2.65, respectively for CO_2, CH_4, N_2O and NH_3 [34].

To compare the pellet induced emissions only (net emissions), emissions from the control plots were subtracted from overall emissions.

2.3. Statistical Analysis

Shapiro-Wilk and Levene tests were used to check the normality of data distribution and assumption of equal variance, respectively. A series of t-tests were performed to investigate if there were any significant differences in ammonia and GHG emissions between compost types, pellet diameter and application method. The interactions between compost types (WCC and SSFC), pellet diameter (6 mm and 8 mm) and application method (MIX and SUP) were tested by the analysis of variance.

All statistical analysis were performed with SPSS software v.24 (IBM Corp. Armonk, NY, USA).

3. Results and Discussion

The emissions of GHG and ammonia can be explained in relation to several variables that include compost type (WCC and SSFC), pellet diameter (6 mm and 8 mm) and application method (MIX and SUP). The analysis of variance highlighted that there were no interactions between the investigated variables.

3.1. Nitrogen Emissions

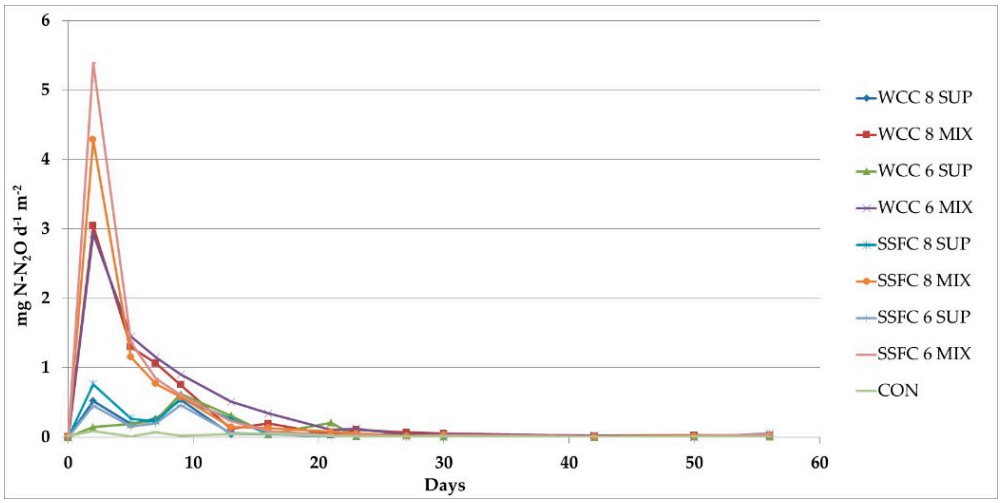
As expected, no NH_3 emission was measured from any of the treatments investigated.

As shown in Figure 1A, during the 57-day incubation period, N_2O emission from all fertilized soils peaked 48 h after pellet application, but then decreased to Control level until the end of the experiment. Peak rates ranged from 0.15 mg N-N_2O day^{-1} m^{-2} (i.e., soil fertilized with WCC 6 SUP) to 5.39 mg·N-N_2O day^{-1} m^{-2} (i.e., soil fertilized with SSFC 6 MIX). Such values are lower than those obtained in a laboratory scale experiment by Fangueiro et al. [35] under favourable conditions to N_2O formation. Factors such as manure type, N application rate, temperature, soil type, moisture content and water holding capacity of the soil have been suggested by Sahrawat and Keeney [36] to affect N_2O production after manure application. As stated by Bertora et al. [37], the peak of N_2O emission occurred during the initial period of fast nitrification and these fluxes can be attributed both to nitrification of the added NH_4^+ and denitrification of the produced NO_3^-. In this context, the soil moisture content adopted in this experiment could promote both nitrification and denitrification [33]. From day 20 to the end of the study, the N_2O emission was similar for all treatments ($p > 0.05$).

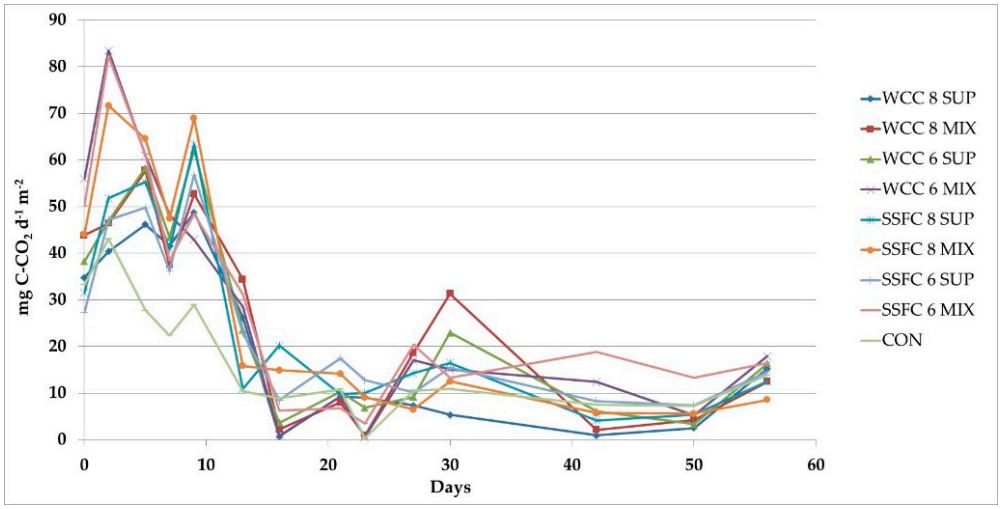
Treatment codes in the legend stands for soil fertilized with: SSFC Ø 6 mm on soil surface applied (SSFC 6 SUP); SSFC Ø 8 mm on soil surface applied (SSFC 8 SUP); SSFC Ø 6 mm incorporated into the soil (SSFC 6 MIX); SSFC Ø 8 mm incorporated into the soil (SSFC 8 MIX); WCC Ø 6 mm on soil surface applied (WCC 6 SUP); WCC Ø 8 mm on soil surface applied (WCC 8 SUP) WCC Ø 6 mm incorporated into the soil (WCC 6 MIX); WCC Ø 8 mm incorporated into the soil (WCC 8 MIX) and Control without pellet (CON). The standard errors have been removed for clarity.

At the end of the experiment, the cumulative amount of N_2O emitted ranged from 2.70 to 24.30 mg N-N_2O m^{-2} for SSFC 6 SUP and SSFC 6 MIX, respectively (Table 3). Less than 0.05% of the total nitrogen applied was lost as N_2O in the treatments in which pellet were applied on soil surface whereas between 0.09% and 0.12% was lost in all treatments characterised by pellet incorporation into the soil (Tables 3 and 4). The obtained results are in line with the study conducted by Fangueiro et al. [24] who found that less than 0.05% of the total N applied as fresh and old cattle solid fraction was lost as N_2O.

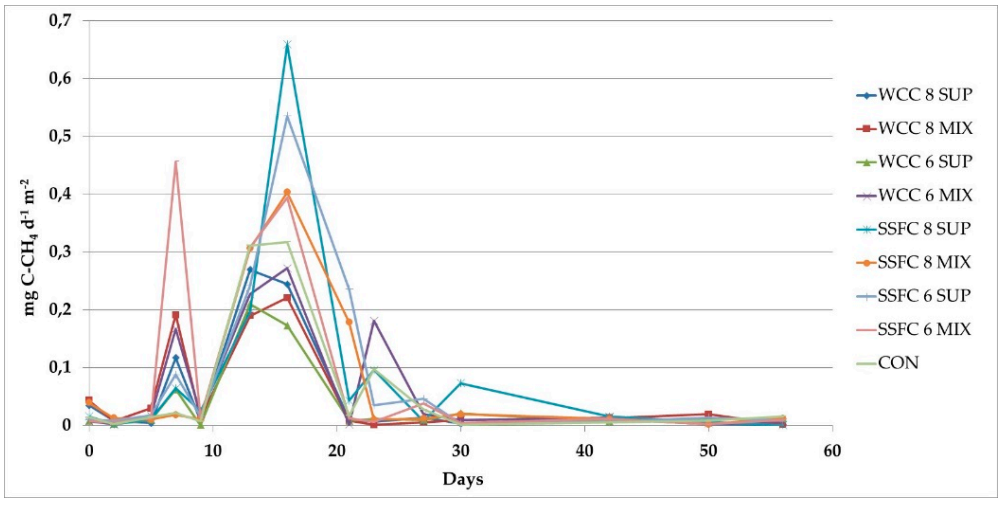
Nitrous oxide emission was significantly affected ($p < 0.05$) by pellet application method: the superficial application resulted in reducing N_2O emission (Figure 2A). This is in line with the study conducted by Zhu et al. [25] who found that the homogeneous distribution (mixed with the soil) of composted pig manure produced higher N_2O emissions than those obtained from superficial application. The results of this experiment are also in accordance with the study conducted by Ambus et al. [38], who found that layered alfalfa and wheat litter amendments depressed N_2O emissions by 1.6 and 6.5 times respectively, compared with evenly distributed litter.



(**A**)



(**B**)



(**C**)

Figure 1. Average N_2O (**A**), CO_2 (**B**) and CH_4 (**C**) fluxes after soil application of the investigated pellet during the 57-days incubation period (n = 4).

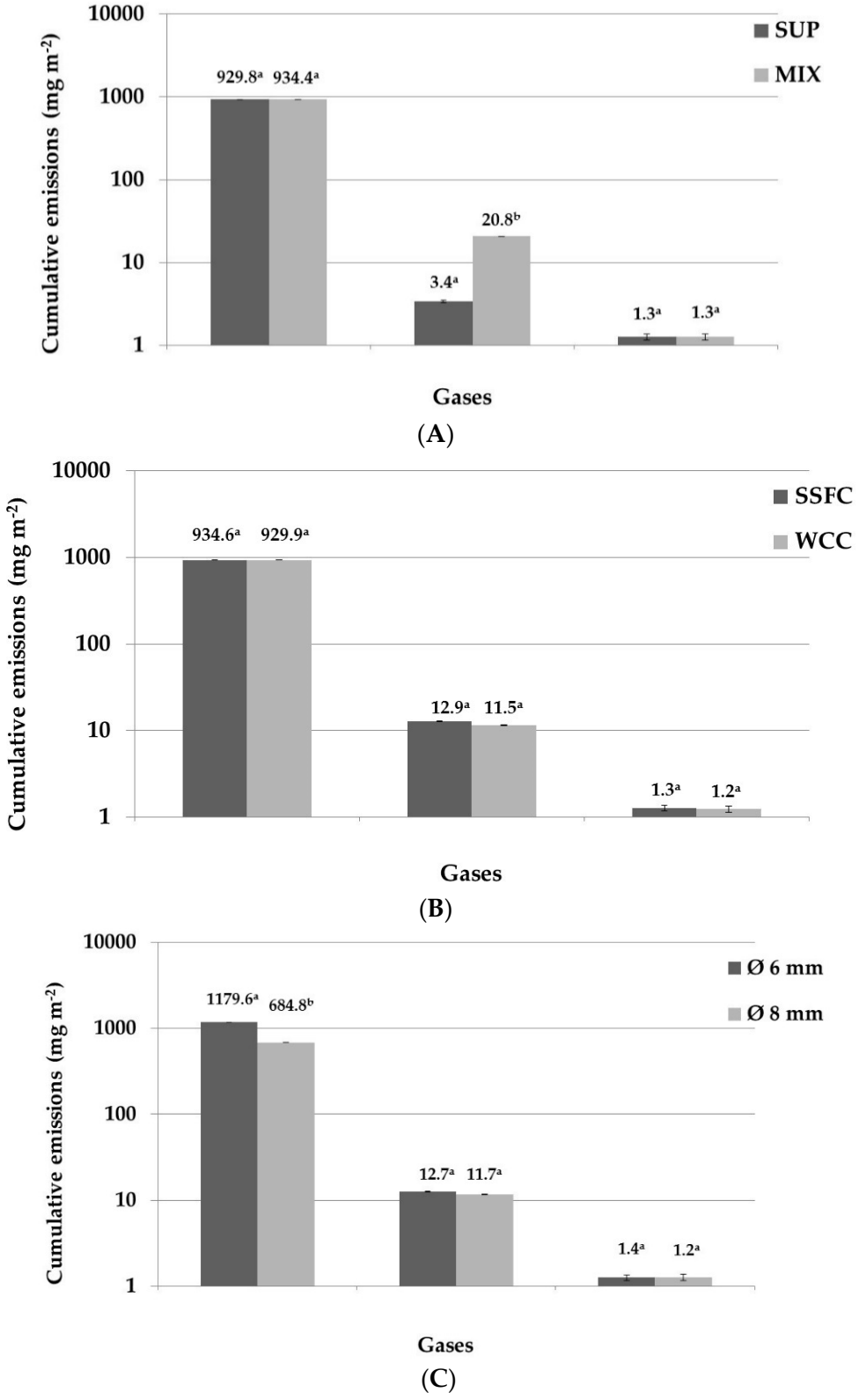


Figure 2. Effect of pellet application system [Superficial and Mixed with the soil] (**A**); compost type [Slurry Solid Fraction Compost and Wood Chips Compost] (**B**) and pellet diameter [Ø 6 mm and Ø 8 mm] (**C**) on cumulative GHG emissions recorded after soil application of the investigated pellet. Error bars represent standard error of the mean. Letters show significant difference ($p < 0.05$).

Table 3. Cumulative CO_2, N_2O and CH_4 emissions after 57-day experimental period related to SSFC (Slurry Solid Fraction Compost) pellet application. Mean value and standard error (in parentheses) of four replicates. Values with different letters are significantly different ($p < 0.05$) within an individual experiment.

Gas	Units	SSFC							
		Ø 6 mm				Ø 8 mm			
		SUP		MIX		SUP		MIX	
CO_2	mg CO_2-C m^{-2}	1170.34 [a]	(33.58)	1101.55 [a]	(37.07)	696.45 [a]	(25.68)	770.11 [a]	(49.16)
	mg CO_2-eq m^{-2} (A)	1170.34	(33.58)	1101.55	(37.07)	696.45	(25.68)	770.11	(49.16)
	% TOC applied	0.44	(0.01)	0.42	(0.02)	0.27	(0.02)	0.29	(0.02)
N_2O	mg N_2O-N m^{-2}	2.70 [a]	(0.17)	24.30 [b]	(1.19)	4.56 [a]	(0.21)	20.09 [b]	(0.62)
	mg CO_2-eq m^{-2} (B)	715.50	(30.73)	6439.50	(52.58)	1208.40	(37.36)	5323.85	(51.17)
	% TN applied	0.01	(<0.01)	0.12	(<0.01)	0.02	(<0.01)	0.10	(<0.01)
CH_4	mg CH_4-C m^{-2}	1.28 [a]	(0.02)	1.26 [a]	(0.02)	1.31 [a]	(0.03)	1.27 [a]	(0.03)
	mg CO_2-eq m^{-2} (C)	35.84	(1.31)	35.28	(1.32)	36.68	(1.39)	35.56	(1.24)
	% TOC applied	<0.01	(<0.01)	<0.01	(<0.01)	<0.01	(<0.01)	<0.01	(<0.01)
Tot mg CO_2-eq. m^{-2} (A + B + C)		1921.68 [a]	(35.83)	7576.33 [b]	(60.05)	1941.53 [a]	(39.25)	6129.52 [b]	(56.25)

Table 4. Cumulative CO_2, N_2O and CH_4 emissions after 57-day experimental period related to WCC (Wood Chip Compost) pellet application. Mean value and standard error (in parentheses) of four replicates. Values with different letters are significantly different ($p < 0.05$) within an individual experiment.

Gas	Units	WCC							
		Ø 6 mm				Ø 8 mm			
		SUP		MIX		SUP		MIX	
CO_2	mg CO_2-C m^{-2}	1162.40 [a]	(32.25)	1144.25 [a]	(31.17)	670.90 [a]	(34.83)	601.89 [a]	(39.02)
	mg CO_2-eq m^{-2} (A)	1162.40	(32.25)	1144.25	(31.17)	670.90	(35.68)	601.89	(39.02)
	% TOC applied	0.37	(0.02)	0.36	(0.02)	0.22	(0.02)	0.19	(0.02)
N_2O	mg N_2O-N m^{-2}	3.35 [a]	(0.17)	20.36 [b]	(0.90)	3.94 [a]	(0.11)	18.30 [b]	(0.49)
	mg CO_2-eq m^{-2} (B)	887.75	(29.21)	5395.40	(42.23)	1044.10	(29.16)	4849.50	(49.82)
	% TN applied	0.02	(<0.01)	0.10	(<0.01)	0.02	(<0.01)	0.09	(<0.01)
CH_4	mg CH_4-C m^{-2}	1.22 [a]	(<0.01)	1.27 [a]	(0.02)	1.25 [a]	(<0.01)	1.23 [a]	(<0.01)
	mg CO_2-eq m^{-2} (C)	34.16	(1.12)	35.56	(1.28)	35.00	(1.09)	34.44	(1.18)
	% TOC applied	<0.01	(<0.01)	<0.01	(<0.01)	<0.01	(<0.01)	<0.01	(<0.01)
Tot mg CO_2-eq. m^{-2} (A + B + C)		2084.31 [a]	(26.01)	6575.21 [b]	(55.55)	1750.00 [a]	(25.55)	5485.83 [b]	(51.27)

3.2. Carbon Emissions

The investigated treatments were characterized by similar CO_2 emission patterns. The peaks of CO_2 emission occurred consistently 3 and 10 days after pellet application (Figure 1B).

During the 57-day incubation period, different amounts of CO_2 were produced by the investigated pellet. Carbon dioxide emission was strongly influenced not only by the amount of C supplied [39], but also by the nature and complexity of C compounds [37]. Since soil pH value measured during the 57-day period was always above the threshold value (7.2) of carbonates dissociation [40], the experimental condition adopted in this experiment did not promote the dissociation of soil and manure carbonates and subsequent chemical CO_2 release. For this reason, all the carbon dioxide emission detected is due to microorganisms-mediated processes, expressly to heterotrophic oxidation of the organic compounds.

At the end of the experiment, cumulative emissions ranged from 601.89 mg C-CO_2 m^{-2} for WCC 8 MIX to 1170.34 mg C-CO_2 m^{-2} for SSFC 6 SUP (Tables 3 and 4). As shown in Figure 2, when pellet diameter is smaller, carbon dioxide emission increased significantly ($p < 0.05$), while compost type and application method did not affect significantly CO_2 emission ($p > 0.05$).

Methane emission increased significantly ($p < 0.05$) relative to the Control 5 days after pellet application. The CH_4 daily fluxes had 2 peaks occurred 7 and 16 days after pellet application and decreased in the following 25 days (Figure 1C). The maximum of CH_4 daily fluxes ranged from 0.17 mg C-CH_4 d^{-1} m^{-2} (i.e., soil fertilized with WCC 6 SUP) to 0.66 mg C-CH_4 d^{-1} m^{-2} (i.e., soil fertilized with SSFC 8 SUP).

Over the 57-day incubation period, the CH_4 cumulative emissions ranged from 1.22 mg C-CH_4 m^{-2} for WCC 6 SUP to 1.31 mg C-CH_4 m^{-2} for SSFC 8 SUP (Tables 3 and 4). The CH_4 emitted during the 57-day period was, for all the investigated treatments, lower than 0.01% of TOC supplied with pellet. The statistical analysis highlighted that there were no significant effects ($p > 0.05$) of pellet diameter, compost type or application method on CH_4 emission (Figure 2).

4. Conclusions

A laboratory scale experiment was carried out in order to determine ammonia and GHG emissions from soil fertilized with pellet made from composted pig slurry solid fraction (applied at equivalent nitrogen rate) and to evaluate the effects of pellet diameter and pellet application method on NH_3, CH_4, N_2O and CO_2 emissions. As expected, ammonia volatilization was not detected from any of the treatments investigated. Considering methane emission, the statistical analysis highlighted that there were no significant effects ($p > 0.05$) of pellet diameter, compost type or application method on CH_4 emission. With regard to N_2O and CO_2 emission, results of the experiment highlighted that superficial application reduced nitrous oxide emission, while when pellet diameter is smaller carbon dioxide emission increased significantly.

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Conflicts of Interest: The authors declare no conflict of interest.

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