Full Length Article

STUDY ON EMISSIONS OF CARBON DIOXIDE FROM GRAZED PASTURE LAND USING CATTLE URINE

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ABSTRACT

An experiment was conducted to assess the effect of application of cattle urine at a rate of 0.7 l/m² area on carbon dioxide (CO_2) emissions under low, medium and high pasture cover blocks of the grazing area during rainy season at Hyderabad. CO_2 emissions was significantly ($P<0.05$) higher in experimental plots which received cattle urine than without cattle urine. Mean CO_2 concentration increased linearly with the time i.e., from 0 to 60 minutes of sample collection under different pasture cover blocks and the differences were significantly ($P<0.01$) different. The CO_2 emissions flux (mg/m²/h) ranged from 9.10 to 28.80, 12.30 to 27.80 and 10.40 to 32.50 with a mean of 16.50 ± 1.24, 17.50 ± 1.00 and 21.30 ± 1.58 mg/m²/hunder low, medium and high vegetation covered chambers, respectively and no trend was observed in CO_2 flux among different vegetative cover blocks.The differences in mean CO_2 emissions flux among different vegetation cover plots were significantly ($P<0.05$) different with highest under high vegetation and lowest under low vegetation cover. It is concluded that, pasture growth would influence the CO_2 emissions from the grazing lands when applied urine of grazing animals hence, appropriate pasture management combined with rotational livestock grazing helps in containing global warming.

Keywords: Carbon dioxide emissions, Cattle urine, Emissions flux, Grazed pastures.

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INTRODUCTION

Cattle excreta deposited on grazed grasslands are a major source of the greenhouse gas (GHG) carbon dioxide (CO_2) emitted into the climate. Currently, many countries use the IPCC default emission factor (EF) of 2% to estimate excreta-derived gases emissions (IPCC, 1996). However, emissions can vary greatly depending on the type of excreta (dung or urine), soil type and timing of application.

Urine patches and dung pats from grazing livestock create hot spots for production and emission of the greenhouse gases, and represent a large proportion in many national agricultural GHGs inventories. Intensively managed and extensively managed grasslands have been identified as an important source of GHGs, largely due to an increase in the stocking density and changes in livestock production systems (De Klein and Eckard, 2008).

Among the anthropogenic sources (agriculture, industry, biomass burning and indirect emissions from reactive N), agriculture plays a dominant role in driving emission growth (Davidson, 1991), contributing 25-30% of all terrestrial biogenic emissions (Tian,*et al.,* 2010). The dominant contribution from agricultural soils is attributed to the expansion of agricultural land area and high N fertilizer use since the pre-industrial era (Reay, 2012).

So far, no systematic study has been conducted on CO_2 emissions from cattle or buffalo urine deposited on grazed pastures in the state of Telangana. Therefore, the present study has been designed to assess the effect of application of cattle urine on carbon dioxide (CO_2) emissions from grazing area during rainy season.

MATERIALS AND METHODS

The present study was carried out at Hayathnagar Research Farm, ICAR- Central Research Institute for Dryland Agriculture (ICAR-CRIDA), Hyderabad during rainy season of the year 2020 in natural grazing lands and analysis was completed at Animal Science Laboratory, ICAR-CRIDA, Santoshnagar, Hyderabad. Urine samples were collected individually from 10 adult cattle maintained at the Dairy unit, Dept. of Livestock Farm Complex, College of Veterinary Science, PVNRTVU, Rajendranagar, Hyderabad.

Experimental plots on grazing fields were classified into 3 treatments, as having either low (T1; <50%), medium (T2; 50-70%) and high (T3; >70%) vegetative cover and these plots were organized following a split-plot design with 5 replicates per treatment. The two treatments were urine application and a control (without urine application). Urine collected in sterile bottles from cattle were applied to independent plots and so there are 5 replicates for each of the control versus urine treatment. Individual replicate plots (1m x 1m) were demarcated within each pasture condition for making measurements of CO_2emissions.

To simulate grazing, grass in each plot was cut to approximately 5 cms ward height, 7 days prior to the beginning of the gas sampling. Prior to starting the experiment, soil sub-samples (0–10 cm) were separately collected from T1, T2 and T3 vegetative cover pastures using augers with 5 cm diameter and combined to give one composite soil sample for each pasture condition. Static chamber bases (10 per treatment) were inserted at the centre of each sub-plot to a depth of 5 cm, 5 days prior to the start of gas sampling. For each treatment, 5 replicate plots were allotted. Cattle urine samples (about 7-10 lit) were collected and immediately 500 ml of the pooled urine was applied to soils to simulate an urination event on soil within each static chamber base at a rate of 0.7 l/m^2.

Gas measurements were conducted from static chambers fitted with two rubber septa (one for gas sampling and another for inserting a thermometer). On each sampling day, chambers were fitted to the chamber bases and sealed with an air-tight rubber belt. Syringes fitted with hypodermic needles were used to collect 4 gas samples from each of static chambers following chamber closure (0 min) and at 15, 30 and 45 minutes after chamber closure. Collected gas samples were transferred to pre–evacuated 10 ml headspace glass vials fitted with rubber butyl septa crimp caps.

Gas sampling frequency

Once before the application of urine (sample day-0), 1 h after urine application, daily for the first 3 days (following urine application; sample day-1, 2 & 3), twice a week during the second and third week (sample day-8, 9, 15 & 16) and once during last week (sample day-22) of the experiment. In each sample day, gas samples were obtained at 0, 15, 30 and 45 minutes. Before start of the experiment, soil temperature was measured using a hand held digital thermometer at gas sampling time by inserting the probe into soil to a depth of 0.10 m **(Sordi *et al*., 2014).**

Analysis by Gas Chromatography

Gas chromatography (GC) consists of Gas Solid Chromatography (GSC) and Gas Liquid Chromatography (GLC). In both types, gas is used as mobile phase, either solid or liquid is used as stationary phase. GSC is not widely used because limited number of stationary phases available and GLC is widely used (Ravishankara *et al.,* 2009).

The carbon dioxide emission measurement was done by using Gas Chromatograph technique (GC-2014, Shimadzu), within a month upon arrival. After sampling, gas samples were analysed on same day for CO_2 concentration using propaq Q column in Thermal Conductivity Detector of 450-GC, BRUKER daltonics, Berman, Germany in the Dept. of Agronomy, ICAR-CRIDA, Santoshnagar, Hyderabad. Hydrogen gas was used as carrier gas for the analysis. Temperature of oven, injector and detector were maintained at 60, 50, 50^0C, respectively. Volume of sample used for analysis was 2 ml.

CO_2 emissions flux was measured using the closed static chamber method (Wang *et al*., 2009). During gas flux determination, a disposable syringe (100 ml) with a 3-way valve was used to collect 200 ml of chamber atmosphere into a sample gas bag (Dalian Hede Technologies Co., Ltd., Dalian, China) at a 15 min interval over a 45 min period and the gas samples were taken as mentioned above. The concentrations of CO_2 in the gas samples were analyzed using a cavity ring-down spectrophotometer (Picarro G1301, Santa Clara, USA). Gas flux was calculated using the following equation:

$$F = \rho \cdot V \cdot \Delta cA \cdot \Delta t$$

- F is the CO_2flux ($mg/m^2/h$)
- ρ is the density of 1 mole CO_2 gas (kg/m^3)

- $\Delta c\ \Delta t^{-1}$ is the rate of change in gas concentration h^{-1}
- *V* and *A* are the volume (m^3) and the chamber base area (m^2)

Statistical analysis

Statistical analysis was conducted using the PROC MIXED procedure of SAS, Cary, NC; SAS/STAT 14.1 (SAS, 2008). Cumulative CO_2 flux will be, correspondingly, log and square root transformed to achieve normality and obtain homogenous variances.

RESULTS AND DISCUSSION

The mean carbon dioxide concentrations (ppm) recorded among different gas sample collection chambers for different sampling days are 446.32 ± 11.81, 553.15 ± 22.94, 660.01 ± 41.13 and 779.46 ± 50.99 at 0, 15, 30 and 45 minutes of sample collection under different vegetative cover blocks were presented in Table 1. The differences in mean

Table 1: Mean Carbon Dioxide (CO_2) Emissions from Different Pasture Cover Plots With or Without Application of Cattle Urine at Different Sampling Times

Sampling Time (min)	Pasture cover plots	Mean(ppm)	± SE
0	Low (T1)	449.33	20.24
	Medium (T2)	435.98	20.22
	High (T3)	456.44	19.04
	Overall Mean ± SEM	**446.32[a]**	**11.81**
15	Low (T1)	549.72	35.85
	Medium (T2)	523.91	27.44
	High (T3)	584.76	51.33
	Overall Mean ± SEM	**553.15[a]**	**22.94**
30	Low (T1)	650.17	59.31
	Medium (T2)	605.33	37.93
	High (T3)	719.62	101.31
	Overall Mean ± SEM	**660.01[a]**	**41.13**
45	Low (T1)	759.80	62.49
	Medium (T2)	706.52	48.23
	High (T3)	864.72	130.93
	Overall Mean ± SEM	**779.46[b]**	**50.99**

[ab]Means in columns with different superscripts differ significantly ($P<0.01$)

CO_2 values among different time intervals (0, 15, 30 and 45 min) were significantly (P<0.01) different. The present results are in accordance with the reports of Boon *et al*. (2014) and this might be due to the pool of available carbon that is added to the soil from livestock excreta provides substrate for the production of carbon dioxide (CO_2) by soil microorganisms.

The data presented in Table 2 depicting that, Carbon dioxide emissions was significantly (P<0.05) higher in the experimental plots received cattle urine than without urine. CO_2 concentrations (ppm) among different chambers with in the low, medium and high vegetative cover plots were variable, but no significant difference was observed. The mean CO_2 concentration of all the gas samples collected at different time intervals, days and vegetation cover during the experimental period was 608.23 ± 18.15 ppm. The CO_2 emissions were significantly (P<0.05) higher in high vegetation cover experimental plots than low to medium vegetation cover plots.

However, no significant difference in CO_2 concentrations (ppm) was observed among low, medium and high vegetative cover blocks either at 0 or 15 or 30 or 45 minutes of gas sampling from collection chambers. These results are in accordance with Lee (2018), who reported increased CO_2 concentration with time in the closed space between the ground and the gas collection chamber as a result of root biomass and microbial respiration in the soil. Kucera and Kirkham (1971) reported that, soil respiration increases with increasing root biomass and that root respiration accounts for 40% of total soil respiration. Similarly, Chapman (1979) gave a value of 70% and Wang *et al*. (2009) reported about 40%, while Coleman (1973) reported only 3-9%.

Carbon dioxide (CO_2) emissions flux

The data presented in Table 3 showing that, the carbon dioxide emissions flux (mg/m^2/h) ranged from 9.10 to 28.80, 12.30 to 27.80 and 10.40 to 32.50 with a mean of 16.50 ± 1.24, 17.50 ± 1.00 and 21.30 ± 1.58 mg/m^2/h under low, medium and high vegetation covered chambers of the experimental field, respecti

The data revealed that, no trend was observed in CO_2 emissions flux among different vegetative cover blocks of the experimental field. The differences in mean CO_2 emission flux values among different vegetation cover plots were significantly (P<0.05) different with highest under high vegetation and lowest under low vegetation cover.

No significant difference in CO_2 emission flux was observed among low, medium and high vegetative cover blocks at 0 or either 15 or 30 or 45 minutes of gas sampling from collection chambers. Carbon dioxide flux values among different chambers with in the low, medium and high vegetative cover were variable but no trend was observed. The mean CO_2 emission flux value of all the gas samples collected at different time intervals, days and vegetation cover during the experimental period recorded was 18.40 ± 0.78 mg/m^2/h. The results of the present study corroborating with the findings of several researchers, who reported that addition of cattle urine can increase the solubility of soil C, leading to increased soil C decomposition and therefore potentially increased CO_2 emission (Clough *et al*., 2003) and leaching (Lambie *et al*., 2012).

Table 2: Mean Carbon Dioxide (CO_2) Emissions from Different Pasture Cover Plots With or Without Application of Cattle Urine

Sampling day	Pasture cover plots	Mean (ppm)	± SE
0	Low (T1)	593.52	35.19
	Medium (T2)	625.60	32.17
	High (T3)	622.99	19.11
	Mean	**614.04[a]**	**16.97**
1	Low (T1)	899.05	174.06
	Medium (T2)	764.44	101.21
	High (T3)	1488.08	344.92
	Mean	**1050.52**	**136.44**
2	Low (T1)	593.74	46.06
	Medium (T2)	459.65	44.65
	High (T3)	539.95	27.83
	Mean	**531.11**	**23.89**
3	Low (T1)	687.59	51.36
	Medium (T2)	712.53	62.17
	High (T3)	626.37	51.70
	Mean	**674.44**	**31.55**
8	Low (T1)	693.37	27.26
	Medium (T2)	664.86	22.93
	High (T3)	663.25	20.16
	Mean	**673.82**	**13.55**
9	Low (T1)	657.49	39.71
	Medium (T2)	672.34	30.79
	High (T3)	591.53	29.62
	Mean	**640.45**	**19.61**
15	Low (T1)	482.37	49.34
	Medium (T2)	442.41	36.84
	High (T3)	507.53	46.29
	Mean	**477.44**	**25.51**

16	Low (T1)	466.97	43.68
	Medium (T2)	440.54	41.70
	High (T3)	483.23	60.58
	Mean	**463.58**	**28.19**
22	Low (T1)	346.19	24.65
	Medium (T2)	338.59	21.15
	High (T3)	389.24	20.91
	Mean	**357.48**	**12.94**
Overall Mean	Low (T1)	602.25	24.98
	Medium (T2)	565.53	18.73
	High (T3)	656.91	44.50
	Overall Mean ± SEM	**608.23^{b}**	**18.15**

^{ab}Means in columns with different superscripts differ significantly (P<0.05)

Table 3: Carbon dioxide (CO_2) Emissions Flux ($mg/m^2/h$) under Different Pasture Cover Plots

Samplingday	Carbon dioxide (CO_2) Emissions Flux ($mg/m^2/h$)		
	Low pasture cover plot (T1)	**Medium pasture cover plot (T2)**	**High pasture cover plot (T3)**
1	25.20	19.70	25.50
2	13.60	17.10	21.20
3	19.30	15.30	25.70
4	19.60	15.40	28.60
5	11.10	15.80	25.30
6	12.50	17.20	31.20
7	14.00	17.60	28.60
8	9.10	13.10	19.80
9	11.70	21.70	32.50
10	14.20	27.80	30.30
11	15.80	22.00	28.10
12	17.40	26.20	25.80

13	18.90	20.40	23.50
14	10.50	24.60	12.00
15	9.40	12.30	10.40
16	12.40	13.60	10.90
17	16.70	12.60	12.30
18	12.20	12.80	12.80
19	17.80	13.00	13.50
20	23.30	13.30	14.10
21	28.80	13.50	14.70
22	28.80	19.90	21.20
Mean ± SE	**16.47[a] 1.24**	**17.50[a] 1.00**	**21.27[b] 1.58**
Overall Mean ± SEM	**18.40 ± 0.78**		

[ab]Means in columns with different superscripts differ significantly (P<0.05)

CONCLUSION

It can be concluded that, pasture growth would influence the CO_2 emissions from the grazing lands when applied urine of grazing animals hence, appropriate pasture management combined with rotational livestock grazing helps in containing global warming.

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