MANURE AMMONIA AND GREENHOUSE GAS EMISSIONS FROM CONDENSED TANNIN FED BEEF CATTLE

by

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ABSTRACT

Greenhouse Gas (GHG), Ammonia (NH_3), and Hydrogen Sulfide (H_2S) emissions from confined animal feeding operations (CAFO) are an emerging concern due to the potential harm to human and animal health and the environment. A study was conducted to determine the effects of three levels of condensed tannins (0, 0.5, and 1.0%, DM basis) fed to 27 beef steers on NH_3 and GHG emissions from manure. Manure and urine were collected from two periods over 6 days. Feces and urine were placed in inert plastic containers and stored separately at -4^{o} C until analysis. Feces and urine were placed in 16.7 x 16.7 x 17 cm plastic chambers and urine was topically added. Gas samples were collected every 24 hours for 1 week, then every 48 hours for 1 week. Headspace samples were injected into a GHG gas chromatograph (GC) for analysis. NH_3 concentrations were measured using a handheld electronic gas detector. H_2S concentrations were measured using a Jerome 631-x hydrogen sulfide analyzer. Tannin inclusion at the 0, 0.5, and 1.0% treatment levels showed a 0, 51, and 57% reduction of NH_3 concentrations in the headspace, respectively (P<0.001). Tannin inclusion in the diet increased CO_2 headspace concentrations (P=0.028). There was no treatment effect on N_2O emissions, (P≥0.123). Results indicate that condensed tannins fed to beef cattle can effectively reduce gaseous NH_3 emissions from confined beef animal facilities.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Chapter 1

Introduction

The United States is the world leader in the fed cattle industry. Nationwide, cattle on feed numbers as of June 1, 2016 were 10.8 million head (NCBA, 2016). This is an increase of 2% from June 1, 2015. Texas leads the nation for cattle on feed with 2.44 million head of cattle (USDA, 2016).

Greenhouse gases (GHG) are theorized to trap heat in the atmosphere, in a phenomenon known as the greenhouse effect. The greenhouse effect, along with natural causes, may contribute to global climate change, including shifts in ecosystems, intensity of severe weather events, and change in temperature and precipitation (Cubasch et al., 2013). While GHGs are essential for human life, and occur from natural sources, human activity is thought to be causing an increase in GHG concentrations present in the atmosphere. The United States 2014 GHG emissions reported by the USEPA (2016a) by gas, are carbon dioxide (CO_2) 80.9%, methane (CH_4) 10.6%, nitrous oxide (N_2O) 5.9%, and fluorinated gases 2.6% (figure 1).

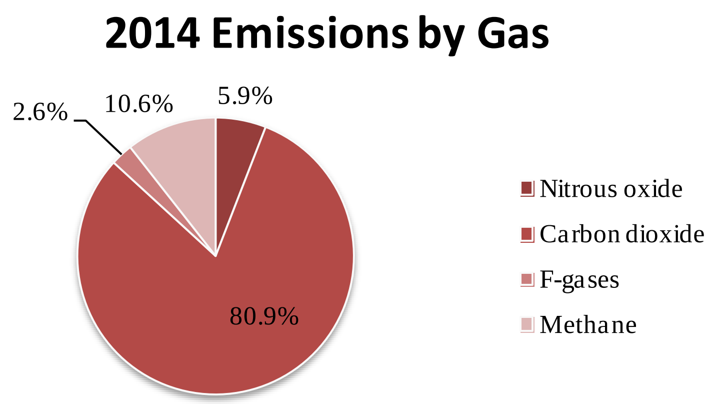

Figure 1: 2014 US Greenhouse Gas Emissions by Gas (USEPA, 2016a)

Greenhouse gas emissions as a result of human activity are: Agriculture 9.1%, Commercial and Residential 12.3%, Industry 21.3%, Transportation 26.3%, and electricity 30.3% (USEPA, 2016a)(figure 2). The breakdown of agricultural emissions is represented in figure 3. Gaseous emissions from livestock raised in Confined Animal Feeding Operations (CAFO) are considered anthropogenic emissions, because the cattle are raised by humans as a food source.

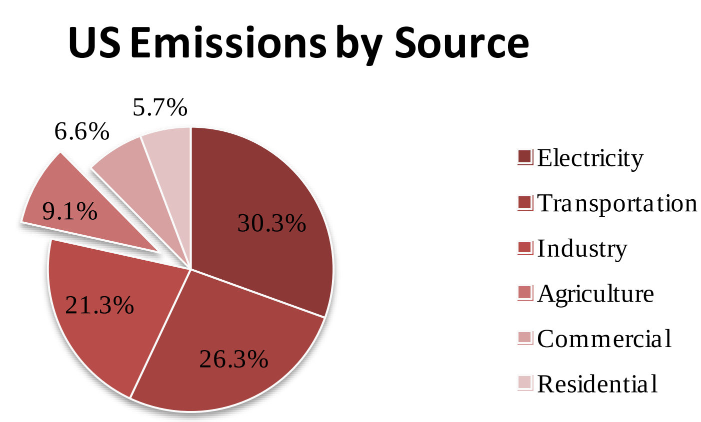

Figure 2: 2014 US Emissions by Sector (USEPA, 2016a)

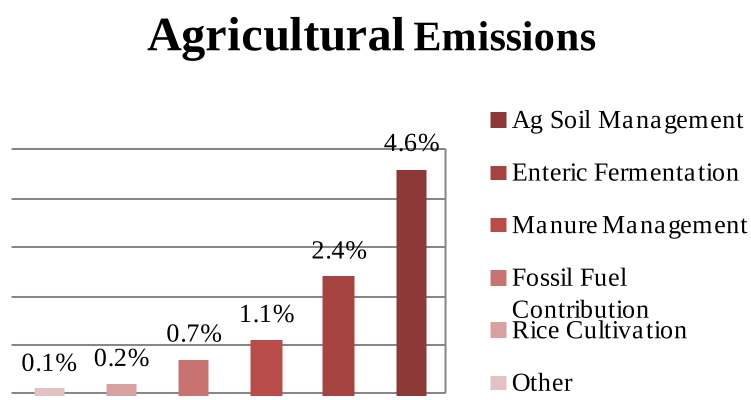

Figure 3: Breakdown of 9.1 % Agricultural Emissions for the US 2014

In addition to GHG, ammonia (NH_3) and hydrogen sulfide (H_2S) are produced in beef cattle feeding operations. Ammonia emissions, primarily from animal wastes, contribute 70-90% of all ammonia emissions in the United States (McQuilling and Adams, 2015). Emissions of NH_3 and H_2S greater than 45.4 kg/day are subject to reporting requirements under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA; 40 C.F.R. Part 302), and the Emergency Planning and Community Right-to-Know Act, due to potential environmental and human health impacts (USEPA, 2004; Leytem et al., 2011; Dai et al., 2015). The importance of reducing gaseous emissions from beef cattle feed operations has grown as public awareness and scrutiny has increased.

Methane

Methane is a colorless, odorless gas, which is extremely flammable (NCBI, 2016). Methane is a natural byproduct of anaerobic bacteria decomposition in areas such as wetlands and marshes.

According to the US Environmental Protection Agency (USEPA, 2016a) CH_4 from human activity, accounts for 60% of all atmospheric CH_4, and is the second most prevalent greenhouse gas emitted in the United States. Methane emissions are becoming an emergent concern because CH_4 is more efficient than CO_2 at trapping radiation, and is thought to have 25 times the climate change potential of CO_2 (USEPA, 2016a).

Methane emissions account for 3.5% of the agricultural GHG emissions (9.1%) totals (USEPA, 2016a). Methane is produced as a part of the natural digestive process in ruminant animals, known as enteric fermentation. Beef cattle are the greatest ruminant contributors of CH_4 (71%), with followed by 25.5% from dairy cattle, and 3.5% from other ruminant animals (USEPA, 2016a). Ruminant animals raised in feeding facilities are thought to contribute between 15 and 33% of global CH_4 emissions (Bodas et al., 2012). Hydrogen produced during ruminal fermentation leads to the generation of methane (Buddle et al., 2011). Methanogens alleviate H_2 concentration in the rume by reducing CO_2, which results in CH_4 formation and eradication by the animal (Bodas et al., 2012). Ruminant livestock eradicate 6% of their ingested energy as CH_4, and can produce 250- 500L of CH_4 per day (Johnson and Johnson, 1995).

Manure storage that promotes anaerobic conditions also produces CH_4. Manure management contributes 12.1% of agricultural GHG emissions, and 8.4% of all agriculture related CH_4 emissions (USEPA, 2016a). The organic matter present in manure is broken down by anaerobic bacteria and methane is a byproduct of the anaerobic breakdown. Temperature, moisture, storage, neutral PH, and residence time effect the amount of methane produced because these factors influence the growth of bacteria responsible for CH_4 production (Smith et al., 2014).

Nitrous Oxide

The global warming potential of N_2O is 298 times CO_2 (Cubasch et al., 2013). Nitrous oxide is a colorless, odorless, non flammable gas (NCBI, 2016). Nitrous oxide emissions contribute 4.9% of all agricultural greenhouse gas emissions (USEPA, 2016a). Manure storage and management contributes to 5.2% of agricultural N_2O emissions. Agricultural soil management is the largest source of N_2O emissions from this sector at 78.9% (USEPA, 2016a).

Cattle consume nitrogen (N) in the form of crude protein (Powell et al., 2011), and convert into body tissue or excrete the excess in feces and urine (Parker et al., 2005). The organic N excreted in feces is made up residues that are mineralized at a much slower rate than volitilization from urea. Nearly equal proportions of N is excreted in feces and urine, with most urinary N, 50-70% present in the form of urea ($CO(NH_2)_2$) (Misslebrook et al., 2005). Urea, when excreted onto soil, is converted by denitrifying bacteria to N_2O, and volatized to the atmosphere (Kronberg and Liebig, 2011)(Figure 4).

N_2O losses are primarily linked to nitrification-denitrification, and volatization of NH_3 (Havlin et al., 2007).

Nitrification of NH_3 :

$$NH_3 + O_2 \rightarrow NO_2^- + 3H \quad (1)$$
$$NO_2^- + H_2O \rightarrow NO_3^- + 2H^+ + 2e^- \quad (2)$$

Biochemical Denitrification of Nitrate (NO_3^-):

$NO_3^- \rightarrow NO_2^- \rightarrow NO \rightarrow N_2O\uparrow \rightarrow N_2\uparrow$

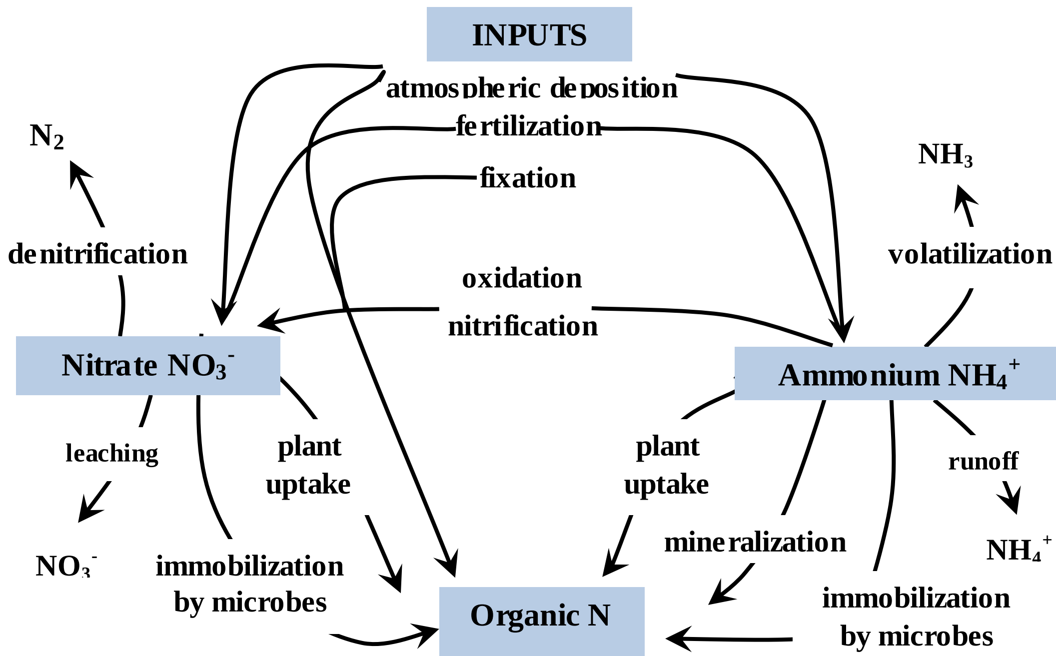

Figure 4: Nitrogen Cycle (adapted from learner.org)

Ammonia

Ammonia is a colorless gas with a pungent, suffocating odor. Ammonia is considered a high health hazard because it is corrosive to the skin, eyes, and lungs. Exposure to 300 parts per million(ppm) NH_3 is immediately dangerous to life and health (NIOSH, 2016). Ammonia is produced commercially, primarily for use as a fertilizer. It is also naturally occurring, from decomposition of organic matter, including plants, animals, and animal wastes.

Seventy to 90% of all NH_3 emissions in the United States are from livestock operations. (Pinder et al., 2004; McQuilling and Adams 2015). Ammonia produced in CAFOs comes from urine spots that have volatized from urea, and from mineralization of feces (Todd et al., 2008).

Ammonification:

$$CO(NH_2)_2 + H^+ + 2H_2O \leftrightarrow 2\ NH_4^+ + HCO_3^-$$

Hydrolysis:

$$2\ NH_4^- + HCO_3^- + 2H^+ \rightarrow 2NH_4^+ + CO_2\uparrow + H_2O$$

Conversion of NH_3 from Ammonium (NH_4^+):

$$NH_4^+ + OH^- \leftrightarrow H^+ + NH_3$$

Ammonia losses begin directly after urine deposition and continue throughout manure handling and land application (Misslebrook et al., 2005). According to Stewart (1970) 25-90% of urinary N is volatized to NH_3 within 48 hours of excretion. Pen surface temperature, air temp, wind speed, moisture content, pH, and N concentration at the source all effect the rate of volatization (Rhoades, 2009). Manure surface pH can be altered by the release of CO_2 which can accelerate NH_3 emission (Ni et al., 2000; Dai et al., 2015).

Ammonia is a precursor to $PM_{2.5}$, which is considered hazardous to human health (Todd et al., 2008; McQuilling and Adams, 2015). Ammonia reacts with acidic compounds like sulfate and nitrate to form particulates (Todd et al., 2008) (figure 4).

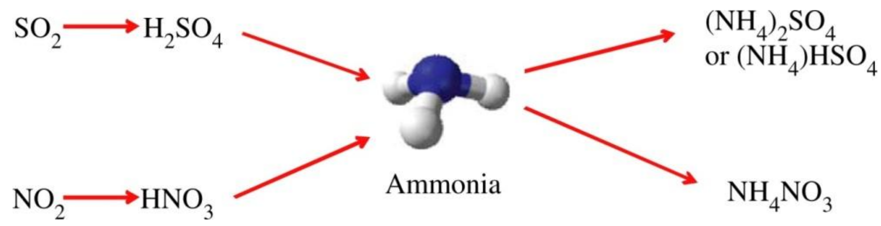

Figure 5: Formation of Fine Particulate Matter From Ammonia (Hristov et al., 2011)

Concerns over potential health hazards from $PM_{2.5}$ emissions have led to regulations by the USEPA National Ambient Air Quality. Particulate Matter has an aerodynamic diameter of < 10µM (PM_{10}) or < 2.5µM ($PM_{2.5}$) (Leytem et al., 2011; Hristov et al., 2011). According to the World Health Organization, air pollution related deaths and illnesses are most closely related to exposure to small particulate matter ≤ 10µM.

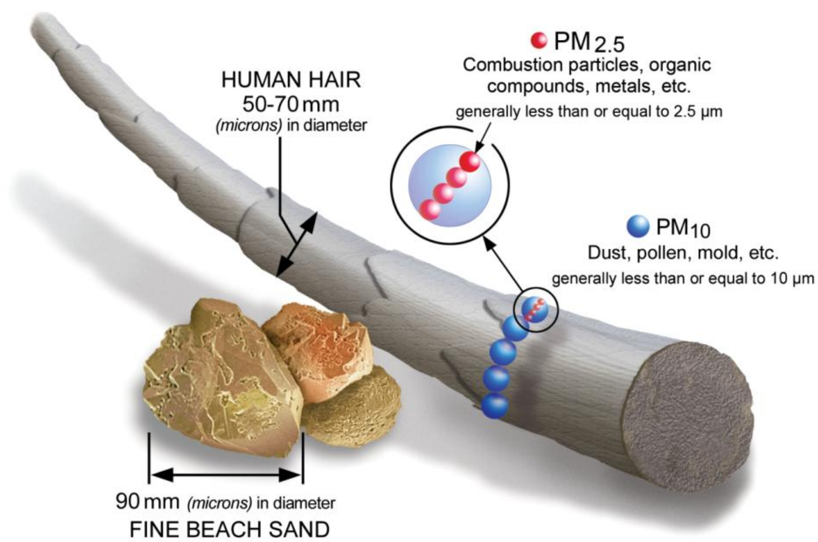

Figure 6: Graphic Showing Relative Size of Particulate Matter (USEPA 2016b)

Carbon Dioxide

Carbon Dioxide is a gas that is naturally present in the Earth's atmosphere as part of the Carbon cycle. 80.9% of all CO_2 emissions are the result of human activity (USEPA, 2016a). Both animal waste and animal respiration contribute to the carbon cycle. Trace amounts of CO_2 are emitted from manure, with the majority of emissions from CAFOs being attributed to energy use from manure management (Beauchemin et al., 2010). Temperature, air velocity, and mass concentration influence CO_2 emission from manure (Ni et al., 2000).

Hydrogen Sulfide

Hydrogen sulfide is a gas of concern due to the danger to human and animal health. Hydrogen sulfide has a strong odor of rotten eggs at low concentrations, is highly flammable, explosive and can be incapaciting or deadly in high concentrations (NCBI, 2016). Under anaerobic conditions, sulfate-reducing bacteria (SRB) produce H_2S (Whitehead et al., 2013). Hydrogen sulfide is a concern in all CAFOs, but is an elevated concern in enclosed feed facilities, where high concentrations have led to human health issues and animal deaths (Dai et al., 2015). Regulatory agencies have proposed the measurement of sulfide levels in animal feeding operations, as a means to control odor (Whitehead et al., 2013).

Oxidation Reduction Potential

Oxidation Reduction Potential (ORP) measures a substance's capacity to either release or accept electrons (Suslow et al., 2004). Oxidation is electron acceptance, and is associated with aerobic conditions. Anaerobic conditions are associated with reduction, which is the release of electrons. Low mV readings represent reduction and high mV readings represent oxidation. Masscheleyn et al. (1993), in a study of CH_4 and N_2O emissions from rice paddies, found that an ORP of -150 mV was critical for the formation of CH_4 and the highest N_2O concentrations were recorded when ORP was +400mV.

Tannins

Tannins are a group of compounds that plants have developed to deter predation by herbivores (Krueger et al., 2010). Red hued seed coats and fruit skins can be an indication of the presence of tannins. Tannins produce an astringent taste in plants when consumed (Mezzomo et al., 2011). Tannin formation occurs as a response to stress or death in plants. Two types of tannins exist in nature, Hydrolyzable Tannins (HT) and proanthocyanidins, more commonly known as Condensed Tannins (CT) (Reed, 1995; Naumann, et al. 2013). They are typically differentiated by molecular weight with CT having a higher molecular weight than HT (Frutos et al., 2004). The higher molecular weight of CT many reduce the ability for tissue absorption. Hydrolyzable tannins can destroy ruminal microbes which can lead to potentially toxic effects in ruminants (Reed, 1995).

Condensed tannins are water soluble polyphenolic compounds synthesized by plants that bind and precipitate proteins (Hagerman et al. 1992; Naumann et al., 2013). Herbaceous plants such as alfalfa and cotton have CT present in their seed coats and hulls (Waghorn et al., 1999). Quebracho tannins are derived from the South American evergreen tree Quebracho Colorado(*Schinopsis balansae*) (Streit and Fengel 1994). Quebracho tannin is a CT produced commercially that has been used as a feed supplement to reduce gaseous emissions from ruminants.

Condensed tannins are reduce the amount of ruminal NH_3 produced which improves the efficiency of urea recycled to the rumen (Reed, 1995). Condensed tannins reduce N excretion in urine by shifting the excreted N from the urine to feces (Kronberg and Liebig, 2011). The biological activities of condensed tannins are related to a combination of factors including molecular weight, degree of polymerization, stereochemistry, hydroxylation, and functional groups within the polyphenolic compound (Naumann et. al. 2013).

Tannin studies are increasing in utilizing tannins to decrease gaseous emissions from ruminants to improve N utilization and reduce urinary N excretion (Hagerman et et al., 1992; Powell et al., 2011). Livestock whose feed has been supplemented CT has shown a reduction in the amount of ammonia produced in the rumen, which improves the absorption of fed N by ruminants (Bodas et al., 2012).

The objective of this study was to investigate the effect of feeding beef cattle diets supplemented with condensed tannins on GHG, NH_3, and H_2S emissions from manure in laboratory simulated feedyard conditions.

Chapter 2

Materials and Methods

Ammonia, greenhouse gas, and hydrogen sulfide concentrations were measured from steers fed diets supplemented with condensed tannin (CT) extract, in a laboratory chamber emission study designed to simulate feedyard conditions. The experiment was located in the Kilgore Research Center Environmental Agriculture Laboratory, on the West Texas A&M University Campus in Canyon, Texas. The chamber study took place over a 45 day period beginning in February 2016. 54 samples of feces and urine, collected previously, were analyzed in three separate runs. Each run utilized 20 chambers for 15 days. Of the 20 chambers, eighteen chambers contained slurry from steers, and two chambers contained no slurry and were utilized as blanks. Headspace concentrations were sampled every 24 hours for 8 days and then every 48 hours for the remainder of the run.

Cattle Feeding and Sample Collection

Cattle were fed, and feces and urine were collected from steers as described in Ebert et al. (2016). Briefly, 27 angus-cross steers (initial body weight = 350 ± 32 kg) were assigned, by initial body weight, randomly to 1 of 3 CT supplementation treatments.

Treatments were three levels of CT added to feed at 0% tannin, 0.5% tannin, and 1.0% tannin on a dry matter basis. Steers were fed using the Calan Broadbent Feeding System (American Calan, Northwood, N.H.) to monitor individual dry matter intake (DMI), and steers had *ad libitum* access to feed. Steers were housed in 3 pens with 9 Calan gates. The diet fed to steers contained 14.0% crude protein (CP), 1.50 NEg Mcal/kg, 8.5% roughage, 60% steam-flaked corn, 15% wet distiller's soluble and 6% fat (DM basis, Table 1). Condensed tannins were added to feed after a grain adaptation period of 21 days.

Table 1. Diet composition

Ingredient composition	DM, %
Steam flaked corn	60.3
Corn wet distiller's grains	15.0
Condensed distiller's soluble	10.0
Sorghum stalks	8.5
Trace mineral premix[1]	3.0
Limestone	1.15
Yellow grease	0.95
Urea	0.8
Salt	0.3
Analyzed nutrient composition[2]	
DM, %	58.65
CP, %	14.0
Starch, %	57.5
NDF, %	16.3
ADF,%	13.4
Ether extract, %	6.1
Ca,%	0.53
P,%	0.45
S,%	0.2
NEm, Mcal/kg[3]	2.16
NEg,Mcal/kg[3]	1.47

[1]Provided to diets (per kg of DM): 0.1 mb Co, 6.3 mg Cu, 0.6mg 1, 37mg Fe, 27 mg Mn, 0.2 mg, Se, 40 mg Zn, 1440 IU Vitamin A, 148 IU Vitamin D, 59 mg Vitamin E, 26 mg Monesin (Elanco Animal Health, Indianaplois, IN), and 5.9 mg Tylosin (Elasnco Animal Health).
[2]Nutrient analysis conducted by commercial laboratory (Servi-Tech Labaoratories, Amarillo, TX.)
[3]Calculated from nutrient analyses according to NRC (1996).

Condensed tannins ((By-Pro: Quebracho extract), 95% tannic acid, Silvateam, Ontario, CA)) were mixed daily with a basal diet to form a premix (10% CT, and 90% basal diet), and were fed as a top dress at either 0.5 or 1% of the diet DM. Dry matter content was adjusted following ingredient sampling and complete diet samples were taken prior to mixing and feeding. Fecal and urine samples were taken over two periods. Period 1 fecal and urine samples were collected after steers were on feed for 34 days. Period 2 samples were collected after 95 days on feed. Urine and feces were collected for 6 days per period, twice daily, with a 2 hour advancement every 24 hours. Urine samples were collected by external catheter. Feces were collected by rectal palpation. Urine was frozen immediately, at -20°C to prevent nitrogen (N) loss. Steers were fed for an average of 126 days to an average final BW of 601 ± 50 kg. Feces and urine samples were frozen and stored until utilized in the chamber study.

Chamber Apparatus Design

The design of the chamber apparatus is similar to the one described in Parker et al. (2005). The chamber design was comprised of 40 - 16.7 X 16.7 X 16.7 cm Tupperware® containers (Figure 7). Each container was attached, by equal lengths Teflon® tubing, to a NH_3 collection trap containing 100 mL 0.2N sulfuric acid (H_2SO_4). Each acid trap was connected to a common center cylinder using equal length tubing to ensure equal airflow to all chambers. The common cylinder was connected to a Marathon Electric, Wausau, WI vacuum pump. Ambient air above the manure was pulled through the acid traps by the vacuum pump (Figure 8). Air flow rate was measured with a flow meter connected to the apparatus, and maintained at 1.4 L/min in each chamber.

Figure 7: Photograph of Chamber Apparatus

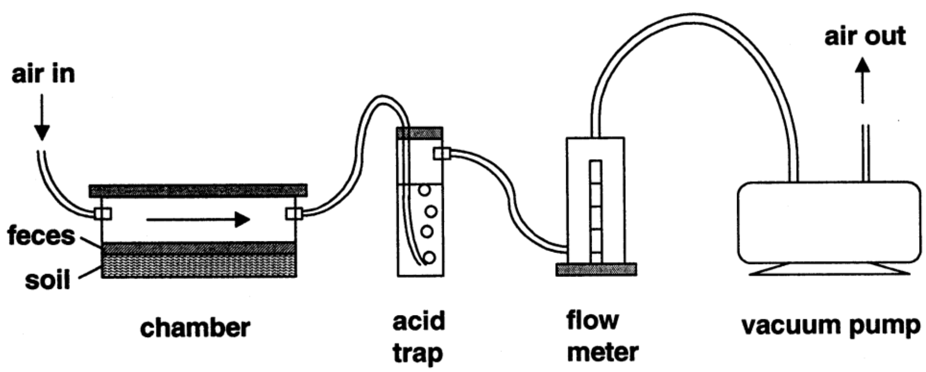

Figure 8: Schematic of Chamber System (Parker et al., 2005)

54 samples were analyzed in three separate runs. Each run utilized 20 chambers. Of the 20 chambers, eighteen chambers contained slurry from steers, and two chambers contained no slurry, and were utilized as blanks.

Twenty chambers were utilized per run, with three runs total for the chamber experiment. Urine and feces were thawed, in their original containers, at room temperature for 24 hours. Urine and feces were weighed separately and combined at a urine to feces ratio of 0.5:1 by weight (Figure 9).

Initial temperature, pH, electrical conductivity (EC), and oxidation reduction potential (ORP) measurements were taken prior to adding the slurry to each chamber. Chambers containing slurry were layered with 1.11 kg of calcined clay, a sheet of Tedlar®, and urine and feces, to replicate a feedyard pen surface. Beef cattle feedyards in the Texas Panhandle are outdoors, with native soil, typically a clay variety, under a hard compacted layer. Cattle deposit urine and feces on top of the compacted layer.

Figure 9: Photograph of Urine and Feces Being Combined

Two chambers were blanks, with no feces or urine added. The clay, Tedlar®, and feces/urine mixture were approximately 6 cm thick in each chamber, leaving approximately 11 cm for headspace accumulation of gases (Figure 10).

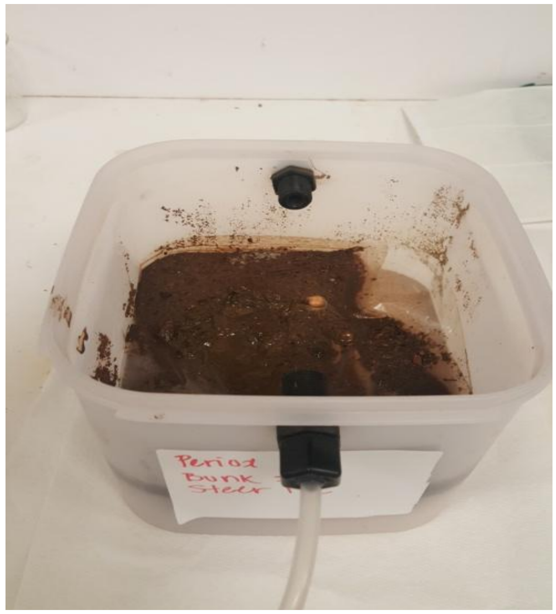

Figure 10: Manure Added to Chambers

Chamber lids were immediately sealed and air flow was started. Urine was added to each chamber every 48 hours, on days 3, 5, 7, 9, and 11, until a urine to feces ratio of 3:1, by weight, was achieved. Urine to feces ratios were determined by the average daily urine and fecal output from the steers.

Sampling

Air flow through the chambers was maintained throughout the sampling process. All headspace gas concentrations were sampled from each chamber within on minute of opening the container lid in order to reduce gaseous losses, and were closed immediately following the collection of samples. Chambers were sampled every 24 hours for the first

7 days, and then every 48 hours for the remainder of each 15 day run. As part of quality control/quality assurance blank air samples, and spike samples were collected and analyzed, in addition to the 2 blank chambers each sample collection day.

Ammonia concentrations were measured with a handheld Mannings Systems, Inc., EC-P2 (Honeywell Industries®, Lincolnshire, IL) gas detector. Measurements were taken from directly from chambers.

Greenhouse gas samples were collected with a Pressure-Lok® Precision Analytical Syringe (Valco Instruments Co. Inc.®, Houston, TX). 1.0 mL samples were immediately injected into a SRI 8610 C Gas Chromatograph (SRI Instruments®, Torrence, CA). Output from the GC was displayed and recorded with Peak Simple Software (SRI Intsruments®, Torrence, CA) (figure 12). Samples were analyzed for CO_2, CH_4, and N_2O concentrations.

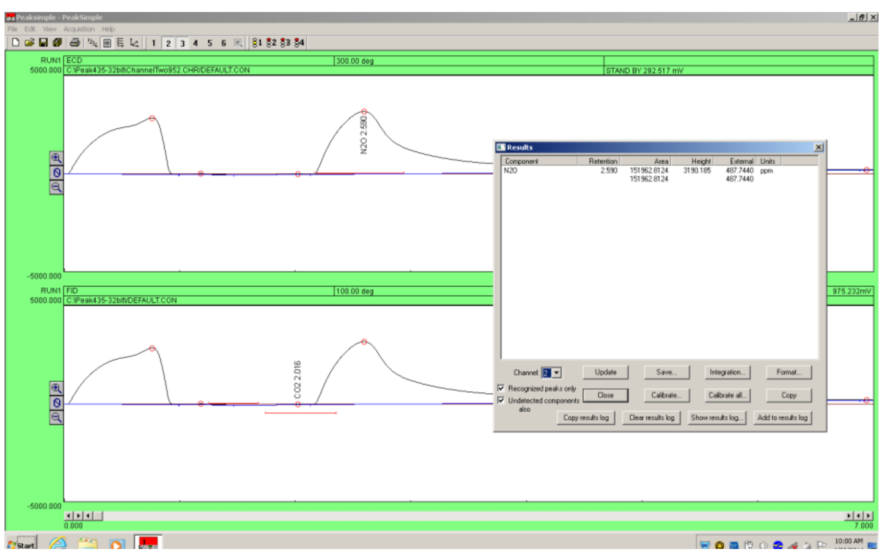

Figure 11: SRI 8610 Peak Simple Display of GHG Results

Hydrogen sulfide concentrations were measured using a Jerome® 631-X Hydrogen Sulfide Analyzer (Arizona Instrument LLC, Chandler, AZ).

Figure 12: Sampling Headspace NH_3 and H_2S Concentrations

Total nitrogen (TN) was calculated from NH_3 concentrations and N_2O headspace concentrations present in the chambers. The concentrations of N_2O (ppb) and NH_3 (ppm) were converted from ppm to mg/m^3.

$$mg/m^3 = (ppmv)(MW)(atm) / (R * T(K))$$

Where:

- atm= pressure
- MW= molecular weight
  - N2O = 44.013
  - NH3 = 17.031
- R= ideal gas constant (0.08206 L atm/(mol K))
- T= Temperature (Kelvin)

The amount of N flux (mg/m^2h) present in the chambers was then calculated by the following equation.

$$J = \Delta CQ/A$$

Where:

- J = flux (mg/m^2h)
- $\Delta C = mg/m^3$ ($C_{out} - C_{in}$)
- Q = Flow Rate (L/min)
- A = Surface Area (m^2)

The amount of N was calculated by taking the percentage of nitrogen present in each compound and adding the N from NH_3 flux calculated to N from N_2O.

$$TN = (N_2O\ mg/m^2h)\ (63.6\%\ N) + (NH3\ mg/m2h)\ (82.24\%N)$$

Initial temperature, pH, EC, and ORP was measured before the slurry was added on top of the Tedlar®, with a sensION™+MM150 (Hach®, Loveland, CO) (figure 13). Final temperature, pH, EC, and ORP was measured at the conclusion of each run. Feces and urine mixtures were frozen for further CH_4 analysis.

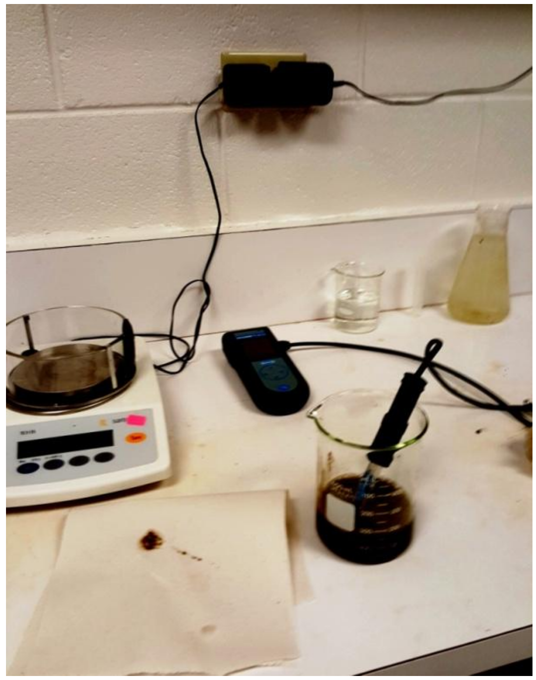

Figure 13: Measuring Initial ORP, Temperature, EC, and pH

Statistical Analysis

Statistical analysis was performed using SPSS Version 22. Ammonia, H_2S, CO_2, and N_2O headspace concentration differences and TN were analyzed as a general linear model in univariate analysis of variance (UNIANOVA) with two independent variables in a completely randomized design. Fixed factors were period and treatment, allowing for analysis of treatment and period effects and treatment by period interaction. Chamber served as experimental unit.

Change in pH, EC, and ORP were determined from day 1 and day 15 values. Delta pH, EC, and ORP were analyzed as a general linear model in UNIANOVA, with two independent variables. Chamber served as experimental unit. Fixed factors were period and treatment. There were no interactions between period and treatment (P<0.05).

Mean separation was determined with Tukey's HSD when ANOVA indicated significant differences. Significance was determined at $\alpha \leq 0.05$.

Chapter 3

Results and Discussion

Ammonia

Mean NH_3 concentrations by treatment are presented in Table 2. The greatest mean concentrations were found in the control (63.95 ppm), while inclusion of CT at 0.5% and 1% resulted in significantly lower ($P < 0.01$) concentrations at 32.89 and 36.57 ppm, respectively. There was no difference among the 0.5% treatment and the 1% CT supplement treatment. However, the means for the 1% supplement level were greater than those in the 0.5% treatment. Headspace concentrations of NH_3 were decreased by 48.57% in the 0.5% treatment, and 42.81% in the 1% treatment.

Treatment means differed in between period 1 and period 2 ($P< 0.01$)(Table 2, Figure 14). While there was not a statistically significant decrease in urinary N (Ebert et al., 2016), there was an average 34% increase in NH_3 headspace concentration from period 1 to period 2 in this study. The treatment concentration means increased by 18.17% (Control), 45.03% (0.5%), and 48.17% (1%).

There was no treatment by period interaction for ammonia concentration ($P\geq 0.79$).

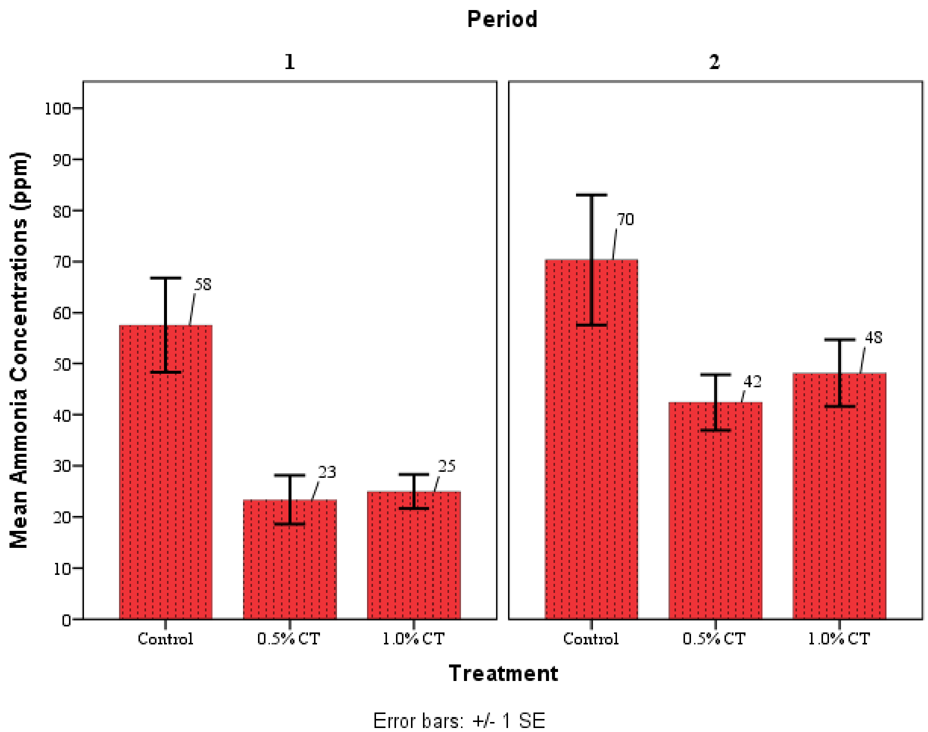

Figure 14: Mean NH_3 Concentrations (ppm) by Period by Treatment

These results are consistent with the findings of Kronberg and Liebig (2011) and Buddle et al. (2011) who did not observe serum urea reductions in beef cattle at or above 1.0% tannin inclusion. Powell et al. (2009) found that high levels of CT included in diet were most effective at reducing cattle manure emissions, when compared to low and medium tannin levels. Misselbrook et al. (2005) conducted a similar manure emission chamber study of cattle fed condensed tannins, and manure from cattle fed condensed tannins emitted lesser amounts of NH_3 than cattle not fed diets supplemented with CT.

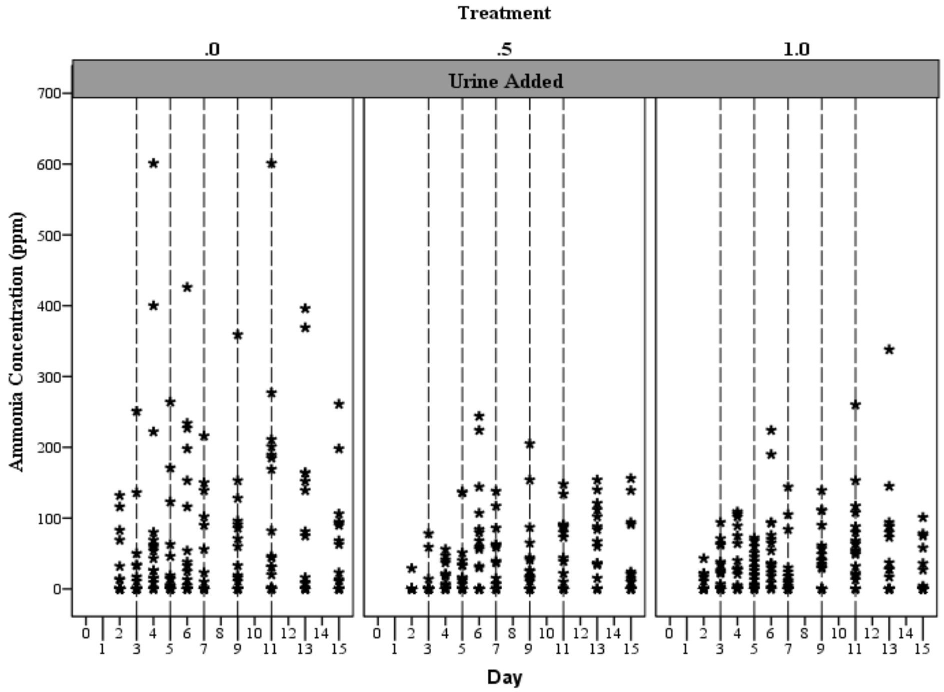

Figure 15: Ammonia Concentrations Following the Addition of Urine. Dotted lines represent days of urine addition.

Headspace concentrations of NH_3 increased in all treatments the day following addition of urine. The greatest increases in headspace concentrations were seen in the control treatment, with lesser increases seen in the 0.5% and 1.0% treatments (Figure 15).

Nitrous Oxide

Nitrous oxide concentrations did not differ among treatments ($P \geq 0.12$)(table 2). However, the greatest mean headspace concentration for N_2O was in the 0.5% treatment (452.3 ppb). Mean concentrations per treatment were lowest in the control treatment (353.22 ppb), and was slightly increased in the 1% treatment (381.66 ppb). Hao et al. (2011) found an increase in NO_3-N with the diet CT inclusion. No statistically significant differences in N_2O emissions were found with tannin inclusion in diet (Hao et al., 2011).

There was no interaction between treatment and period ($P \geq 0.34$)(table 2). There was no difference in headspace N_2O concentrations among periods ($P \geq 0.11$). Mean headspace concentrations were greatest in those treatments that included CTs, and were greater in period 1 contrary to the result of CO_2 and NH_3 (table 3, figure 18). In period 1 the greatest mean concentration was in the 0.5% treatment (526.49 ppm), with 0% (361.24 ppm) and 1% (396.48 ppm) having similar concentrations.

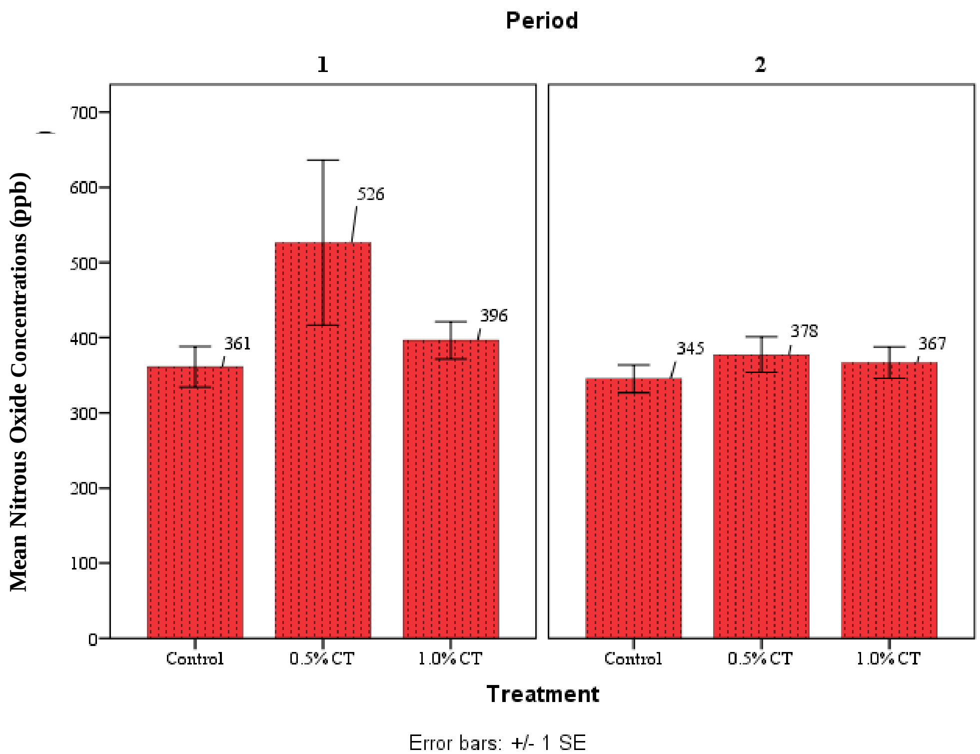

Figure 16: Mean N_2O Concentrations by Treatment and by Period

Headspace concentrations of N_2O were not affected by the addition of urine (Figure 19). This could be attributed to the manure layer remaining undisturbed, with applications of urine made topically. During the composting process peak N_2O emissions are found after turning the compost pile (Maeda. et al., 2010).

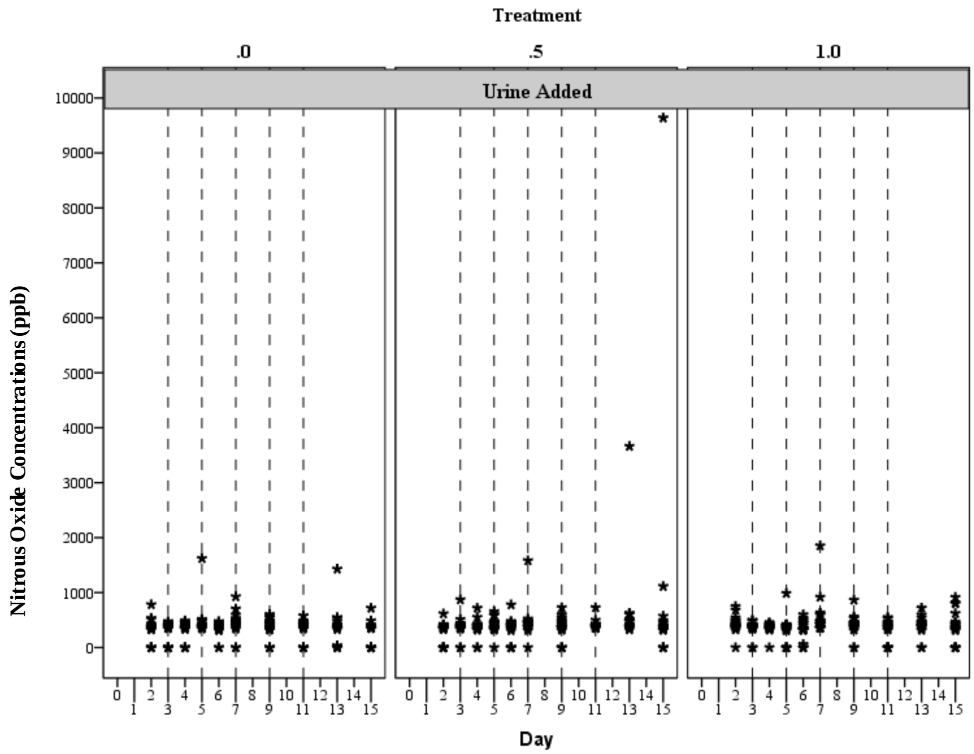

Figure 17: N_2O Concentrations Following the Addition of Urine

Total Nitrogen

There was no period by treatment interaction for total nitrogen ($P \geq 0.80$). Total nitrogen was greater in the control treatment (82.78 mg/m^{2}h)($P \leq 0.01$) than the 0.5% (42.88 mg/m^{2}h) treatment and the 1% treatment (47.42 mg/m^{2}h)(Table 2). There was no difference between the 0.5% and 1.0% treatments (P= 0.89). There was a difference in TN in period 1 and period 2 ($P \leq 0.01$). Period 2 TN (45.96 mg/m^{2}h) treatment means were greater than period 1 (69.43 mg/m^{2}h)(Table 3, Figure 18).

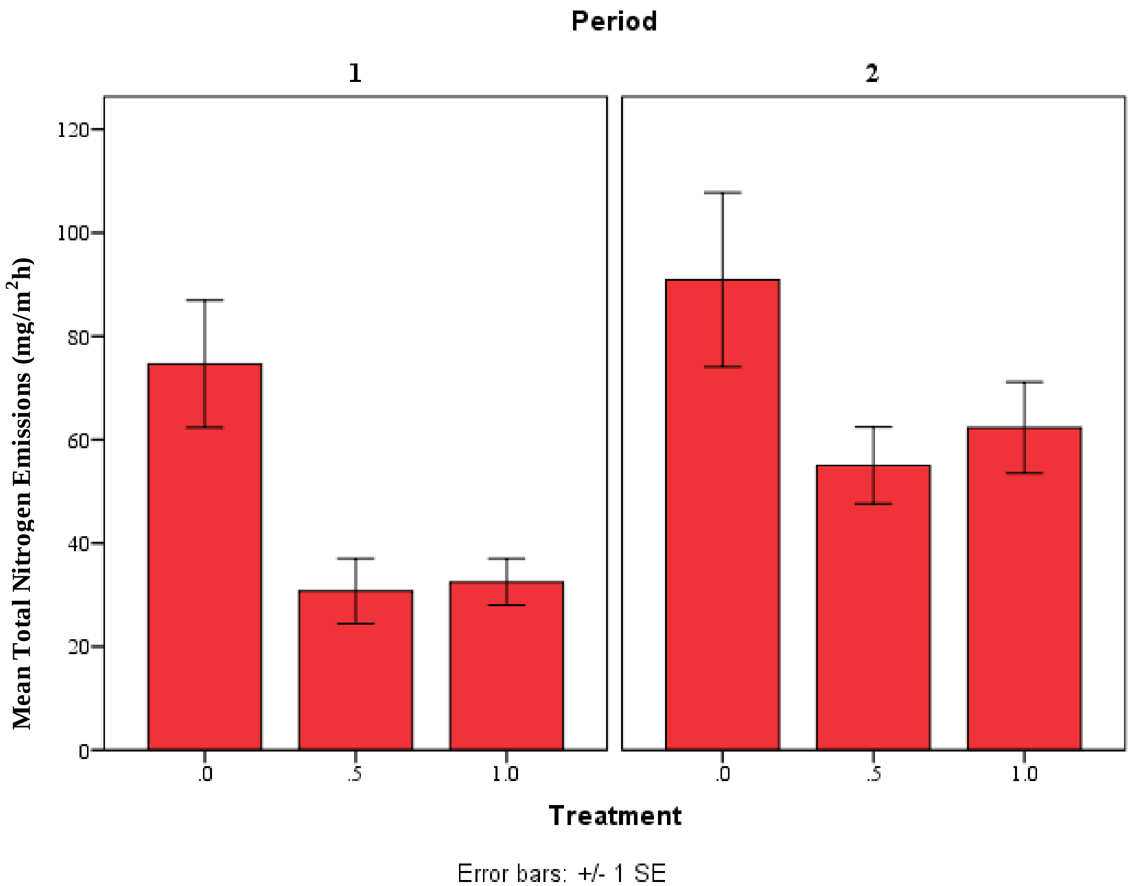

Figure 18: TN Emissions (mg/m^{2}h) by Period by Treatment

Carbon Dioxide

Carbon dioxide concentrations were greater at 0.5% (8,277.72 ppm)(*P*=0.04) than in 0% (5946.54 ppm) treatment and the 1% treatment (7394.84 ppm). The means were different among the control and the 0.5% treatment (*P*=0.03) (Table 2). There was no difference between the means in the 1.0% and the control (*P*= 0.25) or the 1.0% and 0.5% treatments (*P*= 0.59)(Appendix A). There was no difference between periods ($P \geq 0.91$)

(Table 3). There was no treatment by period interaction ($P \geq 0.57$).

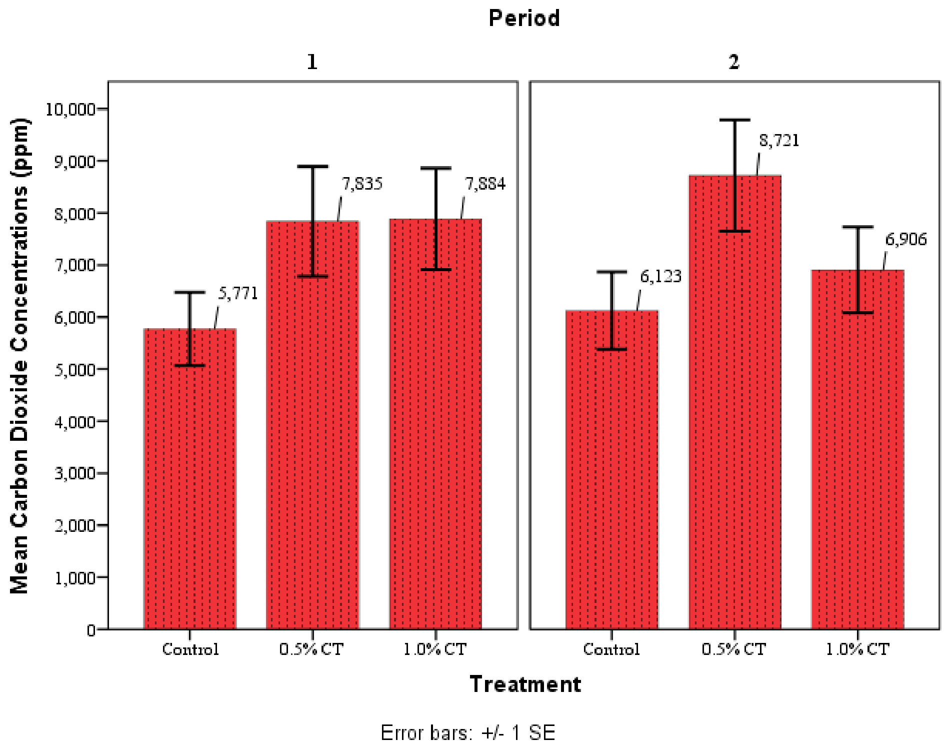

Figure 19: Mean CO_2, Concentrations, By Treatment and Period

While there was no statistical difference between periods, mean concentrations of CO_2 increased in period 2 (Table 3, Figure 16). In period one, the 0.5% and 1.0% means were similar, while in period 2 the 0.5% treatment mean concentrations were 21% greater than the 1.0% treatment, and 30% greater than the control mean concentrations (Table 3, Figure 16).

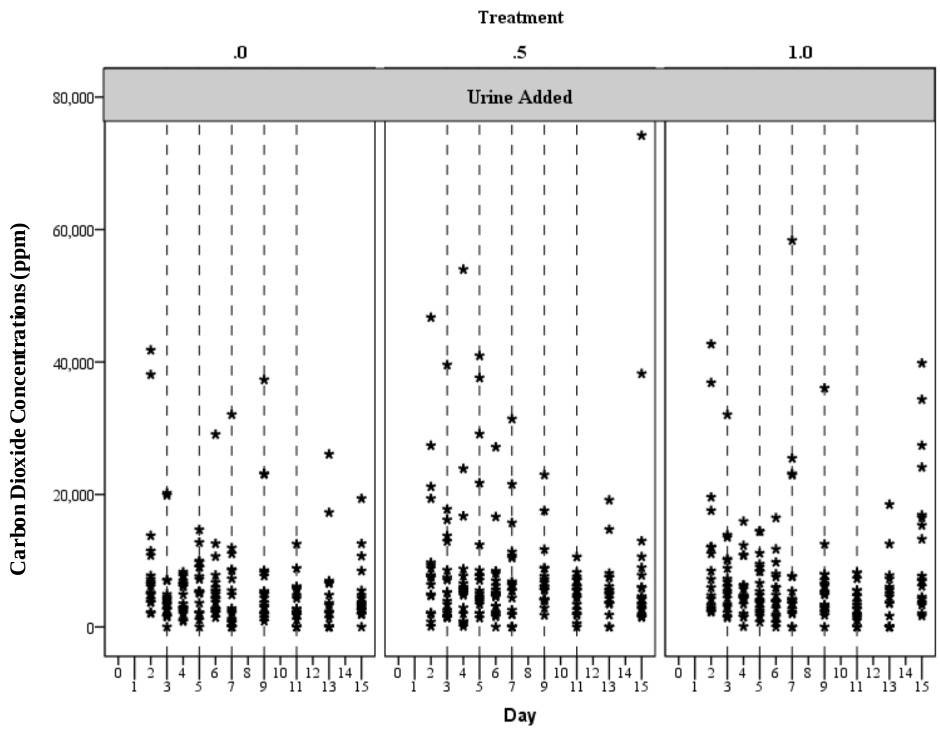

Figure 20: CO_2 Concentrations Following the Addition of Urine, By Treatment

The addition of urine to the chambers did not appear to have an effect on CO_2 concentrations in the headspace. Urine was added to chambers following the collection of samples, and increases were noted before the addition of urine. It is possible that the CO_2 concentrations found in this study were due to higher amounts of C in the feces as opposed to the urine. A study by Al-Kindi et al. (2016) found that while only slight increases were detected, fecal C concentration increased with inclusion level of quebracho tannin extract.

Hao et al. (2011) found that total C content of manure and compost increased with the addition of CT in cattle diets. This same study however showed no difference on CO_2 emissions between diets with CT inclusion and diets without.

Hydrogen Sulfide

There was a treatment by period interaction for H_2S ($P \leq 0.01$)(Table 3). The interaction between treatment and period is in the control (Figure 20). It does not appear that an interaction occurs due to tannin inclusion in the diet.

There was no treatment effect ($P \geq 0.12$)(Table 3) on H_2S headspace concentrations. The control diet had the greatest mean headspace concentration at 1.59 ppm, while the 0.5% and 1.0% treatment means were 1.16 and 1.12 ppm, respectively.

H_2S concentrations were greater in Period 2 than in Period 1 ($P < 0.01$)(Figure 21). The mean control concentrations increased by 62.77%, 0.5% inclusion by 25.56%, and 1.0% inclusion by 25.9% from period 1 to period 2.

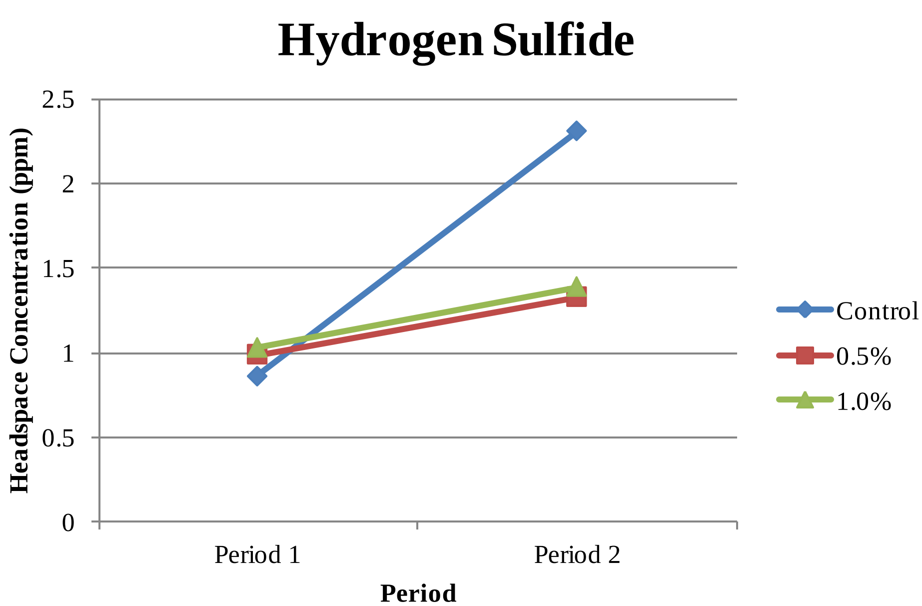

Figure 21: Mean Hydrogen Sulfide Concentrations by Period

The production of H_2S from manure is primarily a result of Sulfate- reducing bacteria present in manure under anaerobic conditions (Whitehead et al., 2013). Tannins inhibitory effect on bacteria is one of the reasons that tannins are effective at reducing CH_4 emissions. There is very limited research available on the effect of CT inclusion in cattle diets on H_2S emissions. In swine manure studies, where CT is added topically to manure after excretion, the addition of 0.5% tannin decreased H_2S production by greater than 90% over the control (Whitehead et al., 2013).

The addition of urine did not affect H_2S headspace concentrations (Figure 22).

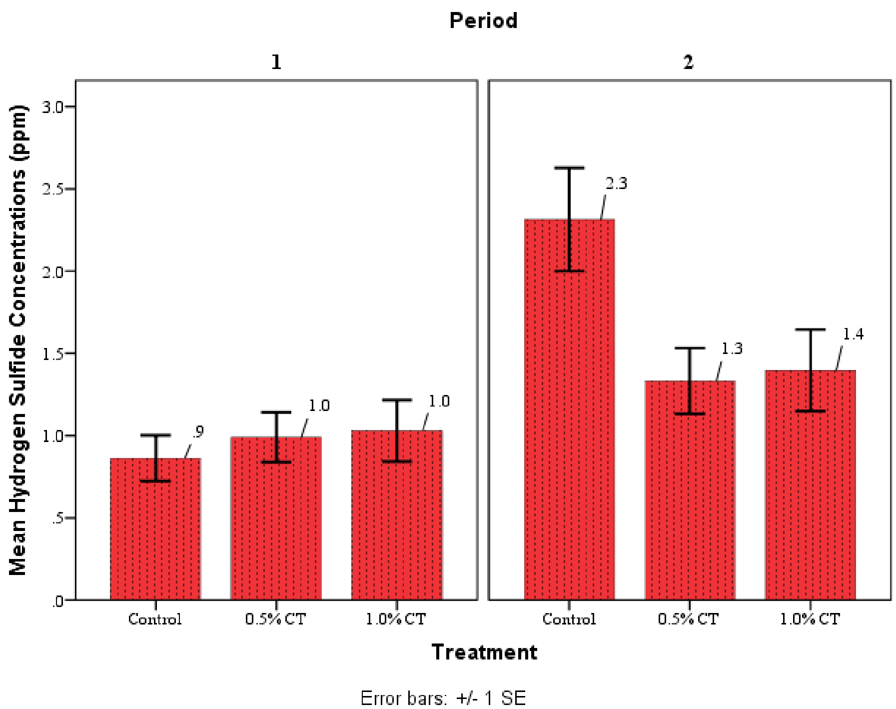

Figure 22: Mean H_2S Concentrations by Period, by Treatment

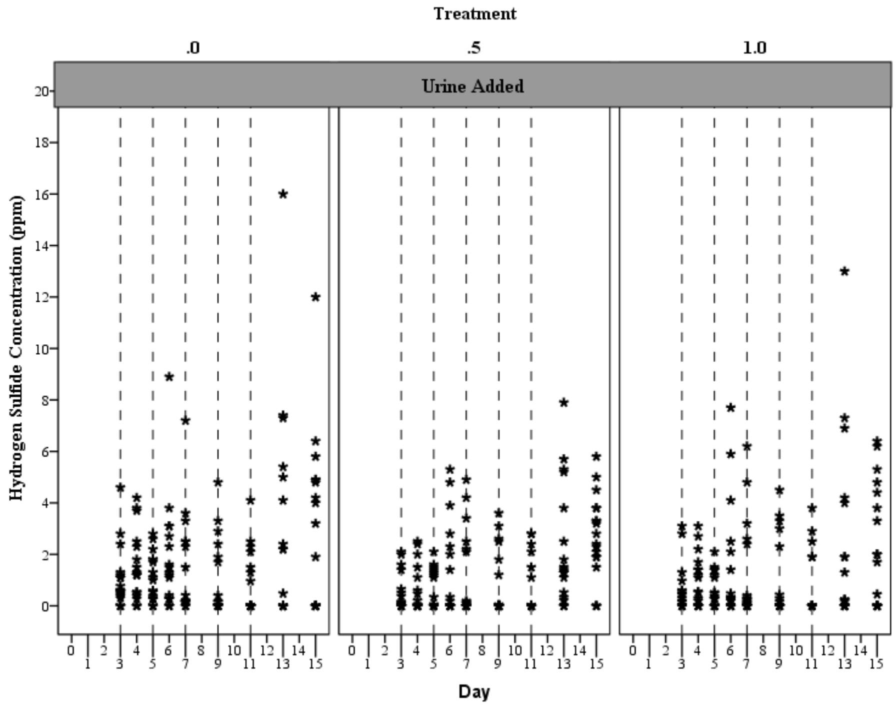

Figure 23: H_2S Concentrations by Treatment With the Addition of Urine. Dashed lines represent day of urine addition.

Oxidation Reduction Potential, pH, and Electrical Conductivity

There was no difference in the change in ORP means among treatments (*P*= 0.22), or periods (*P*= 0.43). The ORP means were similar among all treatments, but the control had the lowest ORP (-281.606mV), followed by the 1% treatment (-264.728 mV), and the .5% treatment (-241.294 mV) (Table 4). The trend across all treatment and all periods was for the ORP to decrease significantly. Xing and Han (2007) found that dinitrogen-N, Nitrogen-N, and CH_4 emissions linearly increased as ORP was reduced. Nitrous oxide emissions were more correlated with oxidized conditions.

Electical conductivity (EC) is a measure of salinity. Salt, as a result of feed additive, is primarily excreted in the feces of ruminant animals (Azeez et al., 2012).

Change in EC was greater in the 1% tannin treatment than in the 0.5% tannin treatment ($P \leq 0.01$) (Table 4). There was no difference between the 0% and 0.5% treatments, or Control and 1% treatments. There was no difference in Δ EC between periods ($P = 0.89$).

The change in pH was not different among treatments ($P = 0.79$), or among periods ($P = 0.05$) (table 4). Initial pH was slightly acidic or neutral at the beginning of the chamber study and increased to basic levels at the final reading. The constant movement of air over manure is thought to increase pH, and some studies suggest that the increase in pH is due to CO_2 emission, and increased pH drives NH_3 emissions. (Hafner et al., 2013; Petersen et al., 2014).

Methane

Methane concentrations were absent through the duration of the study. There are several possibilities for this. First, the conditions inside the chambers were aerobic, due to the constant airflow through the chambers, necessary to pull ammonia emissions through the acid traps. In order for CH_4 to form, conditions must be anaerobic. The ORP in the initial readings and final readings were ideal for the formation of CH_4. The second possibility is that microbes needed for decomposition were slowed when the feces was frozen and it would take longer for the microbes to regenerate in order to produce CH_4 emissions. Finally it is possible that CH_4 flux was too minute to detect.

Table 2: Treatment Mean Headspace Concentrations of NH_3, CO_2, N_2O, and H_2S

	CT extract, % of DM				*P*-value		
Item	0	0.5	1.0	SEM	Treatment	Period	Interaction
No. of observations	180	180	180				
Gas							
NH_3 ppm	63.95[a]	32.89[b]	36.57[b]	7.67	<0.001	0.003	0.792
CO_2 ppm	5946.54[b]	8277.72[a]	7394.84[ab]	906.78	0.035	0.907	0.572
N_2O ppb	353.22	452.03	381.66	49.58	0.123	0.110	0.338
H_2S ppm	1.59	1.16	1.21	0.22	0.096	<0.001	0.014
TN mg/m^{2}h	82.78[a]	42.88[b]	47.72[b]	4.24	<0.001	<0.001	0.801

[a.b] means within the same row with different letters differ at $\alpha = 0.05$

Table 3: Period Mean Headspace Concentrations of NH_3, CO_2, N_2O, and H_2S

	CT extract, % of DM				
Item	0	0.5	1.0	SEM	*P*-value
No. of observations	90	90	90		
Period 1					
NH_3 ppm	57.55	23.33	24.96	3.73	0.004
CO_2 ppm	5770.57	7834.67	7884.16	534.92	0.907
N_2O ppb	361.24	526.49	396.48	38.75	0.110
H_2S ppm	0.86	0.99	1.03	0.09	<0.001
TN mg/m2h	74.64	30.73	32.50	4.95	0.005
Period 2					
NH_3 ppm	70.33	42.44	48.16	5.14	0.004
CO_2 ppm	6122.52	8720.76	6905.52	516.58	0.907
N_2O ppb	345.21	377.56	366.83	12.11	0.110
H_2S ppm	2.31	1.33	1.39	0.15	<0.001
TN mg/m^{2}h	90.93	55.03	62.33	6.83	0.005

Table 4: Change in ORP, EC, and PH by Treatment and Period

	Treatment					Period			
	0	0.5	1	SEM	*P-value*	1	2	SEM	*P-value*
ΔORP mV	-281.606	-241.294	-264.728	9.360	0.221	-255.115	-269.97	9.287	0.431
ΔEC ms/cm	6.749[a]	-0.102[b]	2.0133[ab]	0.834	0.004	2.751	3.023	0.890	0.871
ΔpH	2.306	2.313	2.233	0.52	0.789	2.207	2.361	0.052	0.146

[a.b] means within the same row with different letters differ at $\alpha = 0.05$

Table 5: Initial and Final ORP, EC and pH by Treatment and Period

Treatment	Period	Initial ORP mV	Final ORP mV	Initial EC ms/cm	Final EC ms/cm	Initial pH	Final pH
Control	1	-145.53	-427.89	6.66	14.09	6.57	8.74
	2	-144.92	-425.78	6.54	12.61	6.55	8.99
0.5%	1	-139.39	-372.81	6.60	6.14	6.52	8.88
	2	-151.91	-408.33	7.06	10.42	6.68	8.92
1.0%	1	-121.96	-371.44	7.23	7.23	6.56	8.68
	2	-139.52	-396.22	8.02	11.00	6.56	8.95

Chapter 4

Conclusions

Ammonia concentrations were significantly decreased by inclusion of CTs at the 0.5% and 1.0% level as compared to the control. Period 2 ammonia headspace concentrations were significantly greater than the Period 1 concentrations. As cattle age the amount nitrogen needed by the animal decreases, meaning that more N would be excreted, simply as a factor of age. Total N emissions were decreased by CT inclusion at the 0.5% and 1.0% level as compared to the control. Total N emissions were greater in period 2 than in period 1 in The cattle were fed higher than recommended amounts of N to begin with so the amount of N excreted should be expected to increase as the steer ages.

Carbon dioxide concentrations were not decreased by any tannin treatment, and conversely increased emissions at both tannin inclusion levels.

Condensed tannin inclusion in the diet did not have an effect on Nitrous Oxide concentrations in this study. Hydrogen sulfide concentrations were similar among all treatments, but increased in Period 2. There was an interaction between treatment and period in the control group.

Some studies have suggested that there is a correlation between CO_2 emissions and higher NH_3 emissions, due to CO_2 emissions increasing the surface pH of manure. That does not appear to be the case in this study. Tannin inclusion appears to have an inverse effect on NH_3 and GHG emission.

While indirect N_2O emissions are the result of NH_3 emissions, it appears at least in this study that the main source of N_2O emissions was from the feces portion of the manure.

The combination of the results from all of the gaseous emissions agrees with the hypotheses that CT repartitions N lost from the urine to the feces. While CT are effective at reducing NH_3 and TN, they are not effective at reducing CO_2, N_2O, or H_2S emissions, and can potentially increase these emissions.

Future Research

Further research is needed to determine the effect of CT inclusion on CH_4 emissions from cattle manure. There are several studies available on direct emissions from enteric fermentation sources, but very little research on the effect on manure emissions. Manure CH_4 emissions have the potential to be a valuable resource for biogas generation with anaerobic digesters.

The emission data presented by agencies are based on model calculations and not on empirical data. Emperical data is imperative in order to find areas of weakness or discontinue exploration in areas where they are not truly needed. Laboratory research on manure emissions is essential to the research process as it is more cost effective and easier to control conditions than in the feedlot environment. Finding the cause for the lack of CH_4 emissions in this study is necessary to ensure further laboratory exploration of all GHG emissions. Utilizing fresh manure in a chamber system separate from the NH_3 chamber system, in which air flow is required, would answer many of the CH_4 emission questions not answered during the course of this study. Laboratory research on manure emissions could also be valuable for developing more accurate emissions models.

More research is needed to study the potential to increase GHG and other emissions with CT inclusion. There are several studies available on the effectiveness of CT to reduce NH_3, but very few studies have looked into the consequences of shifting the N fraction to feces. Most studies available in this area are focusing on direct emissions from ruminants, and not from direct manure emission. However, manure N can be a very valuable source of fertilizer N for crops. If efficient methods are discovered to reduce losses from stored manure before land application, the result could be beneficial to farmers and CAFOs.

Hydrogen Sulfide emissions from cattle with CT diet inclusion needs further study. With H_2S being a foremost concern in swine facilities, several researchers have focused on adding tannins topically to manure to reduce emissions. There has been a lot of success in this area and could be beneficial to study in relation to cattle manure. Where this study focused solely on emissions from manure, analyzing Sulfur and C content of the feces could have provided valuable information to accompany emission data collected. A H_2S focused study with the addition of tannins to cattle manure could potentially produce interesting results.

Research will continue with respect to the amount of total N capture in acid traps through this chamber study. Due to time constraints and equipment issues, total N from the acid was not analyzed in time to be included in this study. A correlation between total N, and ORP, EC and PH could provide interesting insight to simple monitoring of emissions through this method. Trends related to urine addition and total N captured based on NH_3 emissions following urine addition are likely

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Appendix A

Headspace Concentration Statistical Tables

Ammonia Tables

Between-Subjects Factors

		Value Label	N
Treatment	.0	Control	180
	.5	0.5% CT	180
	1.0	1.0% CT	180
Period	1		270
	2		270

Descriptive Statistics

Dependent Variable: NH3

Treatment	Period	Mean	Std. Deviation	N
Control	1	57.556	87.3003	90
	2	70.344	120.8696	90
	Total	63.950	105.3301	180
0.5% CT	1	23.333	45.1743	90
	2	42.444	51.5362	90
	Total	32.889	49.2651	180
1.0% CT	1	24.967	31.4709	90
	2	48.167	61.9571	90
	Total	36.567	50.3624	180
Total	1	35.285	61.4311	270
	2	53.652	84.4258	270
	Total	44.469	74.3312	540

Tests of Between-Subjects Effects

Dependent Variable: NH3

Source	Type IV Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	149230.087[a]	3	49743.362	9.425	.000
Intercept	1067822.535	1	1067822.535	202.330	.000
Treatment	103689.937	2	51844.969	9.824	.000
Period	45540.150	1	45540.150	8.629	.003
Error	2828814.378	536	5277.639		
Total	4045867.000	540			
Corrected Total	2978044.465	539			

a. R Squared = .050 (Adjusted R Squared = .045)

Estimated Marginal Means

Grand Mean

Dependent Variable: NH3

Mean	Std. Error	95% Confidence Interval	
		Lower Bound	Upper Bound
44.469	3.126	38.327	50.610

Multiple Comparisons

Dependent Variable: NH3

LSD

(I) Treatment	(J) Treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Control	0.5% CT	31.061*	7.6577	.000	16.018	46.104
	1.0% CT	27.383*	7.6577	.000	12.341	42.426
0.5% CT	Control	-31.061*	7.6577	.000	-46.104	-16.018
	1.0% CT	-3.678	7.6577	.631	-18.721	11.365
1.0% CT	Control	-27.383*	7.6577	.000	-42.426	-12.341
	0.5% CT	3.678	7.6577	.631	-11.365	18.721

Based on observed means.
The error term is Mean Square(Error) = 5277.639.

*. The mean difference is significant at the .05 level.

Ammonia

	Treatment	N	Subset	
			1	2
Tukey HSD [a,b]	0.5	180	32.889	
	1	180	36.567	
	0	180		63.95
	Sig.		0.881	1

Means for groups in homogenous subsets are displayed

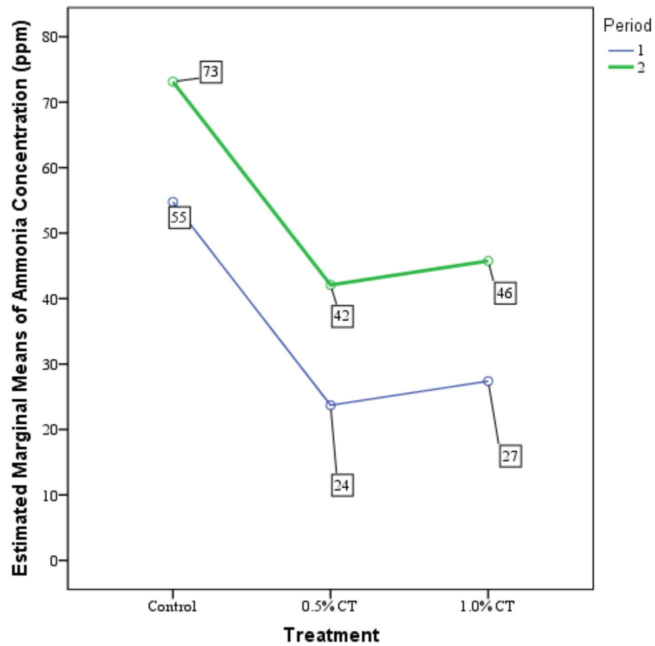
Base on observed means.

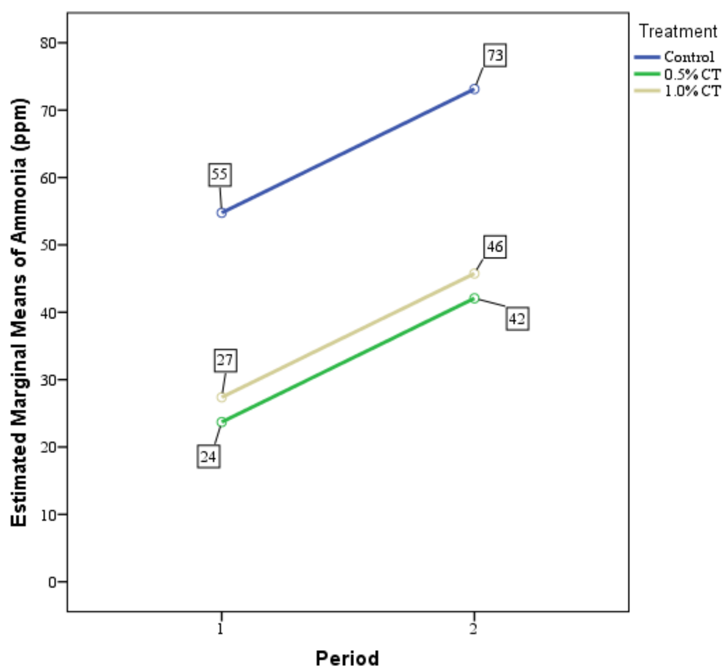
The error term is Mean Square(Error) = 5277.639

a. uses Harmonic Mean Sample Size = 180.000

b. Alpha = .05

Profile Plots





Carbon Dioxide Tables

Descriptive Statistics

Dependent Variable: CO2

Treatment	Period	Mean	Std. Deviation	N
Control	1	5770.571514	6666.3778732	90
	2	6122.515764	7060.1835926	90
	Total	5946.543639	6849.1723170	180
0.5% CT	1	7834.674169	10035.5128902	90
	2	8720.758044	10142.7633902	90
	Total	8277.716107	10070.8632981	180
1.0% CT	1	7884.167084	9242.1531347	90
	2	6905.521745	7839.2329574	90
	Total	7394.844414	8559.5563070	180
Total	1	7163.137589	8789.6935744	270
	2	7249.598518	8488.2125246	270
	Total	7206.368053	8632.3577178	540

Tests of Between-Subjects Effects

Dependent Variable: CO2

Source	Type IV Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	499693349.563[a]	3	166564449.854	2.251	.082
Intercept	28043139880.308	1	28043139880.308	378.949	.000
Treatment	498684158.119	2	249342079.059	3.369	.035
Period	1009191.444	1	1009191.444	.014	.907
Error	39665292925.722	536	74002412.175		
Total	68208126155.593	540			
Corrected Total	40164986275.285	539			

a. R Squared = .012 (Adjusted R Squared = .007)

Estimated Marginal Means

Grand Mean

Dependent Variable: CO2

Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
7206.368	370.191	6479.165	7933.571

Multiple Comparisons

Dependent Variable: CO2

LSD

(I) Treatment	(J) Treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Control	0.5% CT	-2331.172468*	906.7794793	.010	-4112.449809	-549.895126
	1.0% CT	-1448.300776	906.7794793	.111	-3229.578117	332.976566
0.5% CT	Control	2331.172468*	906.7794793	.010	549.895126	4112.449809
	1.0% CT	882.871692	906.7794793	.331	-898.405649	2664.149034
1.0% CT	Control	1448.300776	906.7794793	.111	-332.976566	3229.578117
	0.5% CT	-882.871692	906.7794793	.331	-2664.149034	898.405649

Based on observed means.
The error term is Mean Square(Error) = 74002412.175.
*. The mean difference is significant at the .05 level.

Carbon Dioxide

	Treatment	N	Subset 1	Subset 2
Tukey HSD[a,b]	0.5	180	5946.5436	
	1	180	7394.8444	7394.8444
	0	180		8277.7161
	Sig.		0.248	0.594

Means for groups in homogenous subsets are displayed

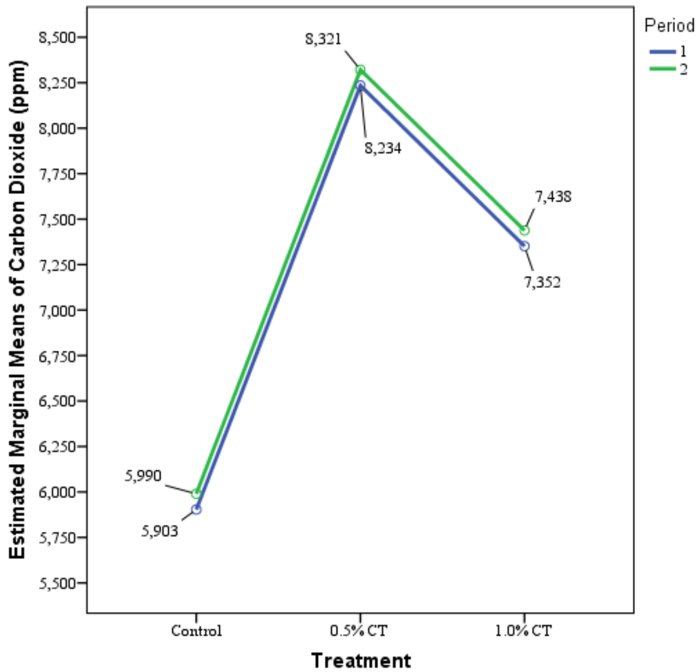
Base on observed means.

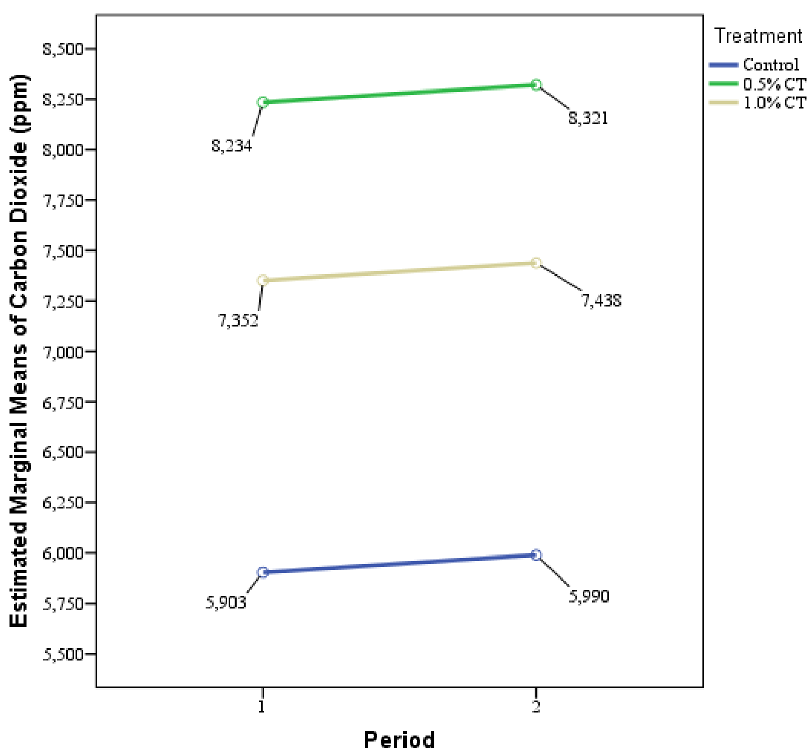
The error term is Mean Square(Error) = 74002412.175

a. uses Harmonic Mean Sample Size = 180.000

b. Alpha = .05

Profile Plots





Nitrous Oxide Tables

Descriptive Statistics

Dependent Variable: N2O

Treatment	Period	Mean	Std. Deviation	N
Control	1	361.241545	256.3764290	90
	2	345.207804	173.6466339	90
	Total	353.224674	218.4898528	180
0.5% CT	1	526.492070	1042.9262270	90
	2	377.560581	222.8233298	90
	Total	452.026326	755.6929660	180
1.0% CT	1	396.482982	234.5766224	90
	2	366.834444	198.1641368	90
	Total	381.658713	217.0373254	180
Total	1	428.072199	636.3103092	270
	2	363.200943	198.9407716	270
	Total	395.636571	472.0972715	540

Tests of Between-Subjects Effects

Dependent Variable: N2O

Source	Type IV Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1499429.484[a]	3	499809.828	2.258	.081
Intercept	84525280.037	1	84525280.037	381.904	.000
Treatment	931311.707	2	465655.854	2.104	.123
Period	568117.777	1	568117.777	2.567	.110
Error	118630644.894	536	221325.830		
Total	204655354.415	540			
Corrected Total	120130074.378	539			

a. R Squared = .012 (Adjusted R Squared = .007)

Estimated Marginal Means

Grand Mean

Dependent Variable: N2O

Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
395.637	20.245	355.867	435.406

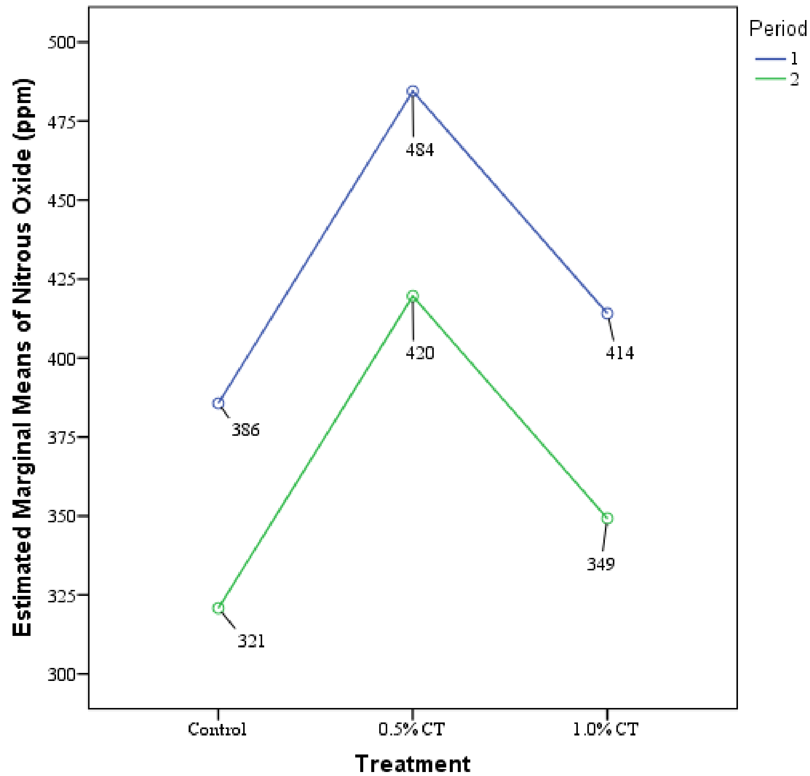
Multiple Comparisons

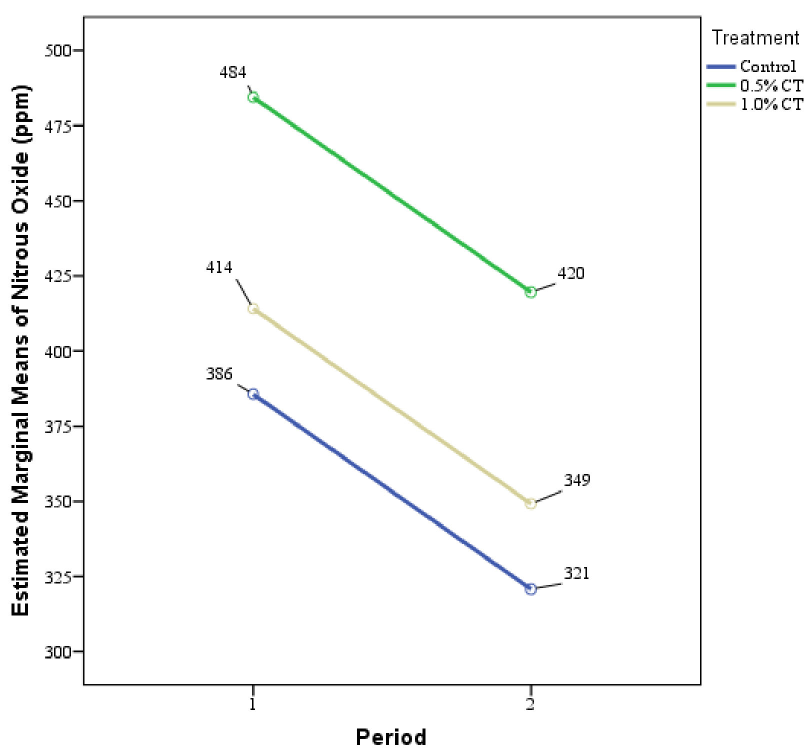
Dependent Variable: N2O
LSD

(I) Treatment	(J) Treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Control	0.5% CT	-98.801651*	49.5900785	.047	-196.216387	-1.386916
	1.0% CT	-28.434039	49.5900785	.567	-125.848775	68.980697
0.5% CT	Control	98.801651*	49.5900785	.047	1.386916	196.216387
	1.0% CT	70.367612	49.5900785	.156	-27.047123	167.782348
1.0% CT	Control	28.434039	49.5900785	.567	-68.980697	125.848775
	0.5% CT	-70.367612	49.5900785	.156	-167.782348	27.047123

Based on observed means.
The error term is Mean Square(Error) = 221325.830.
*. The mean difference is significant at the .05 level.

Profile Plots


Estimated Marginal Means of Nitrous Oxide (ppm)
Treatment
Control
0.5% CT
1.0% CT
Period
1
2
484
420
414
386
349
321


Estimated Marginal Means of Nitrous Oxide (ppm)
Period
1
2
Treatment
Control
0.5% CT
1.0% CT
484
420
414
386
349
321

Hydrogen Sulfide Tables

Tests of Between-Subjects Effects

Dependent Variable: H2S

Source	Type IV Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	113.068[a]	5	22.614	6.047	.000
Intercept	847.977	1	847.977	226.764	.000
Treatment	17.616	2	8.808	2.355	.096
Period	62.985	1	62.985	16.843	.000
Treatment * Period	32.467	2	16.234	4.341	.014
Error	1794.942	480	3.739		
Total	2755.986	486			
Corrected Total	1908.010	485			

a. R Squared = .059 (Adjusted R Squared = .049)

Estimated Marginal Means

Grand Mean

Dependent Variable: H2S

Mean	Std. Error	95% Confidence Interval	
		Lower Bound	Upper Bound
1.321	.088	1.149	1.493

Multiple Comparisons

Dependent Variable: H2S

LSD

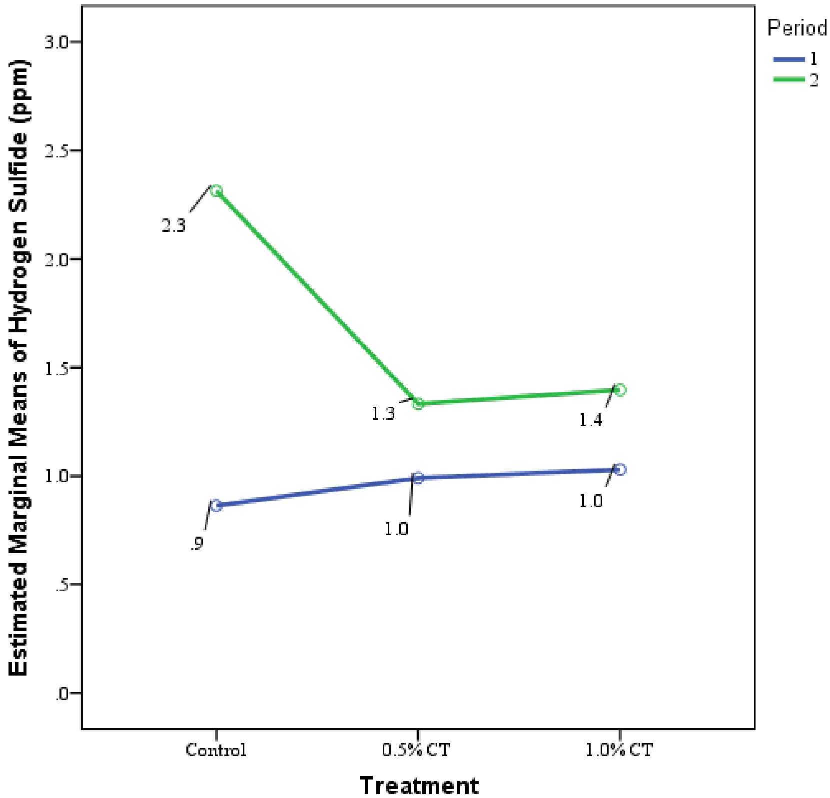
(I) Treatment	(J) Treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Control	0.5% CT	.42716*	.214863	.047	.00497	.84935
	1.0% CT	.37562	.214863	.081	-.04657	.79781
0.5% CT	Control	-.42716*	.214863	.047	-.84935	-.00497
	1.0% CT	-.05154	.214863	.811	-.47373	.37065
1.0% CT	Control	-.37562	.214863	.081	-.79781	.04657
	0.5% CT	.05154	.214863	.811	-.37065	.47373

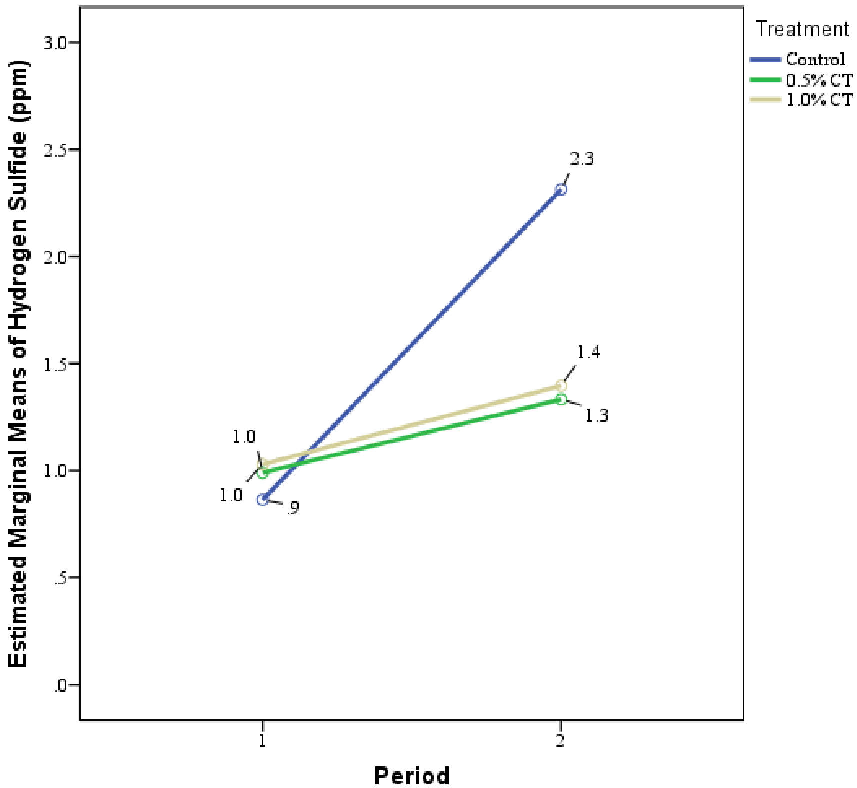
Based on observed means.

The error term is Mean Square(Error) = 3.739.

*. The mean difference is significant at the .05 level.

Profile Plots


Estimated Marginal Means of Hydrogen Sulfide (ppm)
3.0
2.5
2.0
1.5
1.0
.5
.0
2.3
1.3
1.4
.9
1.0
1.0
Control
0.5% CT
1.0% CT
Treatment
Period
1
2


Estimated Marginal Means of Hydrogen Sulfide (ppm)
Period
Treatment
Control
0.5% CT
1.0% CT
3.0
2.5
2.0
1.5
1.0
.5
.0
1
2
2.3
1.4
1.3
1.0
1.0
.9

Total Nitrogen Tables

Tests of Between-Subjects Effects

Dependent Variable: TN

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	300402.536[a]	5	60080.507	5.322	.000
Intercept	2156878.329	1	2156878.329	191.052	.000
Treatment	206160.041	2	103080.020	9.131	.000
Period	89242.754	1	89242.754	7.905	.005
Treatment * Period	4999.741	2	2499.870	.221	.801
Error	7247861.891	642	11289.505		
Total	9705142.755	648			
Corrected Total	7548264.427	647			

a. R Squared = .040 (Adjusted R Squared = .032)

Multiple Comparisons

Dependent Variable: TN

	(I) Treatment	(J) Treatment	95% Confidence Interval Upper Bound
Tukey HSD	.0	.5	63.92
		1.0	59.38
	.5	.0	-15.88
		1.0	19.49
	1.0	.0	-11.35
		.5	28.55
LSD	.0	.5	59.98
		1.0	55.44
	.5	.0	-19.82
		1.0	15.54
	1.0	.0	-15.29
		.5	24.61

Based on observed means.
The error term is Mean Square(Error) = 11289.505.
*. The mean difference is significant at the 0.05 level.

Homogeneous Subsets

TN

	Treatment	N	Subset	
			1	2
Tukey HSD[a,b]	.5	180	42.88	
	1.0	180	47.42	
	.0	180		82.78
	Sig.		.897	1.000

Means for groups in homogeneous subsets are displayed.
Based on observed means.
The error term is Mean Square(Error) = 11289.505.

a. Uses Harmonic Mean Sample Size = 216.000.
b. Alpha = 0.05.

Appendix B

Chamber Headspace Concentrations and Data

Day	Treatment	Period	Bunk	Feces (g)	Urine (g)	ORP mv	EC ms/cm	pH	CO_2 ppm	N_2O ppb	CH_4 ppb	NH_3 ppm	H_2S ppm
Day 0	1	1	63	125.55	63.206	-126.9	7.12	6.19	.	.	.	.	.
Day 1	1	1	63	.		.	.	.	.	.	.	.	.
Day 2	1	1	63			.	.	.	11996.262	325.80876	0	0	.
Day 3	1	1	63		63.206	.	.	.	10085.396	409.32786	0	7	.
Day 4	1	1	63			.	.	.	10790.62	320.06818	0	0	0.55
Day 5	1	1	63		63.206	.	.	.	5360.7695	353.57566	0	45	1.1
Day 6	1	1	63			.	.	.	1526.2205	0	0	18	0.48
Day 7	1	1	63		63.206	.	.	.	2732.5903	482.86336	0	0	0.4
Day 9	1	1	63		63.206	.	.	.	2204.1143	0	0	0	0.29
Day 11	1	1	63		63.206	.	.	.	0	0	0	19	0.014
Day 13	1	1	63			.	.	.	0	418.93708	0	37	0
Day 15	1	1	63			-295	7	8.97	24097.188	799.43728	0	0	0
Day 0	1	2	23	165.199	82.713	-169.2	6.06	5.91	.	.	.	.	.
Day 1	1	2	23			.	.	.	.	.	.	.	.
Day 2	1	2	23			.	.	.	4742.8164	349.42622	0	0	.
Day 3	1	2	23		82.713	.	.	.	3037.7242	492.94057	0	3	0.57
Day 4	1	2	23			.	.	.	4624.5561	368.14549	0	5	0.2
Day 5	1	2	23		82.713	.	.	.	4041.8042	327.58709	0	4	0.29
Day 6	1	2	23			.	.	.	645.90142	0	0	0	0.3
Day 7	1	2	23		82.713	.	.	.	3509.4021	446.14241	0	0	0.24
Day 9	1	2	23		82.713	.	.	.	36055.072	321.34733	0	0	0.43
Day 11	1	2	23		82.713	.	.	.	1697.3954	0	0	0	0.017
Day 13	1	2	23			.	.	.	0	474.3149	0	0	0
Day 15	1	2	23			-311	8.25	8.68	27396.23	814.2879	0	0	0

Day	Treatment	Period	Bunk	Feces (g)	Urine (g)	ORP mv	EC ms/cm	pH	CO_2 ppm	N_2O ppb	CH_4 ppm	NH_3 ppm	H_2S ppm
Day 0	blank	blank	1A			.	.	.	.	.	.	.	.
Day 1	blank	blank	1A			.	.	.	.	.	.	.	.
Day 2	blank	blank	1A			.	.	.	0	384.30645	0	0	0
Day 3	blank	blank	1A			.	.	.	0	426.48719	0	0	0.012
Day 4	blank	blank	1A			.	.	.	0	414.41326	0	0	0.042
Day 5	blank	blank	1A			.	.	.	0	371.26536	0	0	0.038
Day 6	blank	blank	1A			.	.	.	0	0	0	0	0.029
Day 7	blank	blank	1A			.	.	.	0	489.82069	0	0	0.021
Day 9	blank	blank	1A			.	.	.	0	0	0	0	0.011
Day 11	blank	blank	1A			.	.	.	0	0	0	0	0
Day 13	blank	blank	1A			.	.	.	0	474.2213	0	0	0
Day 15	blank	blank	1A			.	.	.	0	527.5088	0	0	0
Day 0	**blank**	**blank**	**1B**			**.**	**.**	**.**	**.**	**.**	**.**	**.**	**.**
Day 1	blank	blank	1B			.	.	.	.	.	.	.	.
Day 2	blank	blank	1B			.	.	.	0	396.22438	0	0	0
Day 3	blank	blank	1B			.	.	.	0	371.26536	0	0	0
Day 4	blank	blank	1B			.	.	.	0	439.90266	0	0	0.034
Day 5	blank	blank	1B			.	.	.	0	414.94364	0	0	0.03
Day 6	blank	blank	1B			.	.	.	0	508.53995	0	0	0.029
Day 7	blank	blank	1B			.	.	.	0	452.38217	0	0	0.019
Day 9	blank	blank	1B			.	.	.	0	415.8796	0	0	0.009
Day 11	blank	blank	1B			.	.	.	0	0	0	0	0
Day 13	blank	blank	1B			.	.	.	0	0	0	0	0
Day 15	blank	blank	1B			.	.	.	0	393.1045	0	0	0

Day	Treatment	Period	Bunk	Feces (g)	Urine (g)	ORP mv	EC ms/cm	pH	CO_2 ppm	N_2O ppb	CH_4 ppm	NH_3 ppm	H_2S ppm
Day 0	1	1	55	156.969	78.609	-153.7	7.55	6.43	.	.	.	.	.
Day 1	1	1	55			.	.	.	.	.	.	.	.
Day 2	1	1	55			.	.	.	2354.7521	424.30327	0	11	.
Day 3	1	1	55		78.609	.	.	.	6038.9022	368.14549	0	62	0
Day 4	1	1	55			.	.	.	3441.554	455.50204	0	89	0.52
Day 5	1	1	55		78.609	.	.	.	3818.2097	414.94364	0	60	0.49
Day 6	1	1	55			.	.	.	697.62753	499.18032	0	30	0.33
Day 7	1	1	55		78.609	.	.	.	0	424.30327	0	4	0.23
Day 9	1	1	55		78.609	.	.	.	2838.9293	455.50204	0	40	0.17
Day 11	1	1	55		78.609	.	.	.	0	327.58709	0	49	0
Day 13	1	1	55			.	.	.	0	404.11767	0	89	0
Day 15	1	1	55			-396	10.21	9.09	7680.3512	327.58709	0	36	0
Day 0	0	1	56	152.348	76.627	-214	8.39	7.1	.	.	.	.	.
Day 1	0	1	56			.	.	.	.	.	.	.	.
Day 2	0	1	56			.	.	.	2180.2857	399.34426	0	83	.
Day 3	0	1	56		76.627	.	.	.	3486.035	443.02253	0	136	1.1
Day 4	0	1	56			.	.	.	6108.7072	349.42622	0	400	2.3
Day 5	0	1	56		76.627	.	.	.	3603.2054	409.01587	0	171	1.8
Day 6	0	1	56			.	.	.	5449.6169	471.10143	0	227	1.2
Day 7	0	1	56		76.627	.	.	.	645.97426	0	0	139	0.17
Day 9	0	1	56		76.627	.	.	.	2031.459	486.70081	0	96	0.16
Day 11	0	1	56		76.627	.	.	.	1775.1254	0	0	185	0
Day 13	0	1	56			.	.	.	0	0	0	164	0
Day 15	0	1	56			-487	14.15	9.1	10690.277	0	0	94	0

Day	Treatment	Period	Bunk	Feces (g)	Urine (g)	ORP mv	EC ms/cm	pH	CO_2 ppm	N_2O ppb	CH_4 ppm	NH_3 ppm	H_2S ppm
Day 0	0	1	42	136.15	68.163	-69.3	5.82	6.25	.	.	.	.	.
Day 1	0	1	42			.	.	.	.	.	.	.	.
Day 2	0	1	42			.	.	.	4870.0484	533.49897	0	0	.
Day 3	0	1	42		68.163	.	.	.	2789.7914	377.50512	0	11	0.31
Day 4	0	1	42			.	.	.	835.92641	0	0	15	0.28
Day 5	0	1	42		68.163	.	.	.	5211.8185	396.22438	0	0	0.38
Day 6	0	1	42			.	.	.	2756.3287	399.34426	0	0	0.27
Day 7	0	1	42		68.163	.	.	.	827.25359	0	0	0	0.18
Day 9	0	1	42		68.613	.	.	.	37318.384	433.6629	0	0	0.17
Day 11	0	1	42		68.163	.	.	.	0	0	0	31	0
Day 13	0	1	42			.	.	.	0	0	0	0	0
Day 15	0	1	42			-318	5.43	8.72	8454.515	0	0	0	0
Day 0	0.5	1	43	131.252	65.844	-118.8	6.47	6.01	.	.	.	.	.
Day 1	0.5	1	43			.	.	.	.	.	.	.	.
Day 2	0.5	1	43			.	.	.	86.694168	0	0	0	.
Day 3	0.5	1	43		65.844	.	.	.	1669.9843	383.74487	0	0	0.11
Day 4	0.5	1	43			.	.	.	507.06838	0	0	0	0.049
Day 5	0.5	1	43		65.844	.	.	.	2064.4313	433.6629	0	0	0.048
Day 6	0.5	1	43			.	.	.	8420.7896	418.06352	0	0	0.19
Day 7	0.5	1	43		65.844	.	.	.	0	467.98155	0	0	0.19
Day 9	0.5	1	43		65.844	.	.	.	22952.816	436.78278	0	0	0.042
Day 11	0.5	1	43		65.844	.	.	.	0	383.74487	0	0	0.028
Day 13	0.5	1	43			.	.	.	4847.0254	502.3002	0	0	0
Day 15	0.5	1	43			-389	4.49	8.68	10594.486	405.58401	0	0	0

Day	Treatment	Period	Bunk	Feces (g)	Urine (g)	ORP mv	EC ms/cm	pH	CO_2 ppm	N_2O ppb	CH_4 ppm	NH_3 ppm	H_2S ppm
Day 0	0	1	47	108.6466	54.412	-166	7.78	6.85	.	.	.	.	.
Day 1	0	1	47			.	.	.	.	.	.	.	.
Day 2	0	1	47			.	.	.	4171.7896	380.62499	0	14	.
Day 3	0	1	47		54.412	.	.	.	4069.0901	377.50512	0	34	0.58
Day 4	0	1	47			.	.	.	2775.7333	358.78586	0	222	1.8
Day 5	0	1	47		54.412	.	.	.	1081.3147	502.3002	0	46	0.28
Day 6	0	1	47			.	.	.	12573.267	464.86167	0	54	1.1
Day 7	0	1	47		54.412	.	.	.	0	416.19159	0	56	0.18
Day 9	0	1	47		54.412	.	.	.	869.93298	474.2213	0	71	0.021
Day 11	0	1	47		54.412	.	.	.	1090.9781	467.98155	0	277	0
Day 13	0	1	47			.	.	.	6941.0169	545.97848	0	139	0
Day 15	0	1	47			-458	17.5	8.99	3011.6695	0	0	94	0
Day 0	0	1	65	163.155	81.148	-112.1	5.67	6.58	.	.	.	.	.
Day 1	0	1	65			.	.	.	.	.	.	.	.
Day 2	0	1	65			.	.	.	6128.1215	0	0	13	.
Day 3	0	1	65		81.148	.	.	.	4929.1896	474.2213	0	17	1.2
Day 4	0	1	65			.	.	.	7931.9409	358.78586	0	54	1.2
Day 5	0	1	65		81.148	.	.	.	5231.8398	355.66598	0	0	1.7
Day 6	0	1	65			.	.	.	3732.3313	361.90573	0	25	1.3
Day 7	0	1	65		81.148	.	.	.	0	483.58094	0	0	0.41
Day 9	0	1	65		81.148	.	.	.	4378.5281	439.90266	0	0	0.036
Day 11	0	1	65		81.148	.	.	.	2629.1355	439.90266	0	82	0
Day 13	0	1	65			.	.	.	0	0	0	8	0
Day 15	0	1	65			-354	5.29	8.53	12563.758	371.26536	0	0	0

Day	Treatment	Period	Bunk	Feces (g)	Urine (g)	ORP mv	EC ms/cm	pH	CO_2 ppm	N_2O ppb	CH_4 ppm	NH_3 ppm	H_2S ppm
Day 0	1	2	55	219.753	109.814	-150.1	7.4	6.68	.	.	.	.	.
Day 1	1	2	55			.	.	.	.	.	.	.	.
Day 2	1	2	55			.	.	.	12051.072	499.18032	0	21	.
Day 3	1	2	55		109.814	.	.	.	10238.352	386.86475	0	35	0.97
Day 4	1	2	55			.	.	.	1519.1316	349.42622	0	102	1.7
Day 5	1	2	55		109.814	.	.	.	9483.8311	383.74487	0	19	1.4
Day 6	1	2	55			.	.	.	7561.7729	321.34733	0	93	1.4
Day 7	1	2	55		109.814	.	.	.	3991.6466	371.26536	0	9	0.3
Day 9	1	2	55		109.814	.	.	.	7924.9483	386.86475	0	31	0.024
Day 11	1	2	55		109.814	.	.	.	1026.8615	545.97848	0	117	0
Day 13	1	2	55						0	315.10758	0	73	0
Day 15	1	2	55			-467	11.85	8.9	16506.708	359.75302	0	75	0
Day 0	0	1	62	160.303	80.022	-126.3	6.9	6.15	.	.	.	.	.
Day 1	0	1	62			.	.	.	.	.	.	.	.
Day 2	0	1	62			.	.	.	7728.2366	330.70696	0	0	.
Day 3	0	1	62		80.022	.	.	.	3709.1682	380.62499	0	0	0.4
Day 4	0	1	62			.	.	.	6953.5346	456.12602	0	26	1.3
Day 5	0	1	62		80.022	.	.	.	7607.9632	474.2213	0	0	2.8
Day 6	0	1	62			.	.	.	10637.685	358.78586	0	0	0.41
Day 7	0	1	62		80.022	.	.	.	1148.6965	496.06044	0	0	0.13
Day 9	0	1	62		80.022	.	.	.	7698.5956	327.58709	0	0	0
Day 11	0	1	62		80.022	.	.	.	5637.612	439.90266	0	31	0
Day 13	0	1	62			.	.	.	0	355.66598	0	0	0
Day 15	0	1	62			-443	10.81	8	19372.775	407.23754	0	0	0

Day	Treatment	Period	Bunk	Feces (g)	Urine (g)	ORP mv	EC ms/cm	pH	CO_2 ppm	N_2O ppb	CH_4 ppm	NH_3 ppm	H_2S ppm
Day 0	0	1	56	148.898	72.726	-112.1	6.5	6.64	.	.	.	.	.
Day 1	0	1	56			.	.	.	.	.	.	.	.
Day 2	0	1	56			.	.	.	3726.3244	336.94672	0	69	.
Day 3	0	1	56		72.726	.	.	.	0	414.94364	0	33	0.61
Day 4	0	1	56			.	.	.	1067.6984	486.70081	0	59	0.54
Day 5	0	1	56		72.726	.	.	.	0	383.74487	0	14	0.28
Day 6	0	1	56			.	.	.	7810.8323	393.1045	0	116	0.27
Day 7	0	1	56		72.726	.	.	.	8514.4036	405.58401	0	23	0.15
Day 9	0	1	56		72.726	.	.	.	2931.3875	399.34426	0	91	0.008
Day 11	0	1	56		72.726	.	.	.	4719.7843	377.50512	0	189	0
Day 13	0	1	56			.	.	.	1337.2426	35.25461	0	16	0
Day 15	0	1	56			-409	12.96	8.78	0	0	0	0	0
Day 0	0.5	1	48	106.815	53.856	-19.2	6.81	6.73	.	.	.	.	.
Day 1	0.5	1	48			.	.	.	.	.	.	.	.
Day 2	0.5	1	48			.	.	.	6396.6388	377.50512	0	0	.
Day 3	0.5	1	48		53.856	.	.	.	3402.2107	374.38524	0	1	0.15
Day 4	0.5	1	48			.	.	.	91.43848	427.42315	0	0	0.21
Day 5	0.5	1	48		53.856	.	.	.	3429.147	467.98155	0	0	0.34
Day 6	0.5	1	48			.	.	.	27151.882	436.78278	0	0	0.34
Day 7	0.5	1	48		53.856	.	.	.	0	393.1045	0	0	0.13
Day 9	0.5	1	48		53.856	.	.	.	3979.3269	602.13626	0	0	0.007
Day 11	0.5	1	48		53.856	.	.	.	1990.2316	405.58401	0	0	0
Day 13	0.5	1	48			.	.	.	0	324.81039	0	0	0
Day 15	0.5	1	48			-312	4.85	8.72	74199.72	1113.7961	0	0	0

Day	Treatment	Period	Bunk	Feces (g)	Urine (g)	ORP mv	EC ms/cm	pH	CO_2 ppm	N_2O ppb	CH_4 ppm	NH_3 ppm	H_2S ppm
Day 0	1	1	68	153.622	77.02	-110.4	7.56	6.85	.	.	.	.	.
Day 1	1	1	68			.	.	.	.	.	.	.	.
Day 2	1	1	68			.	.	.	2905.7867	748.77048	0	0	.
Day 3	1	1	68		77.02	.	.	.	4355.3658	421.1834	0	94	0.6
Day 4	1	1	68			.	.	.	4393.8788	430.54303	0	106	1.4
Day 5	1	1	68		77.02	.	.	.	2874.718	358.78586	0	51	0.38
Day 6	1	1	68			.	.	.	5930.7688	599.01638	0	70	0.32
Day 7	1	1	68		77.02	.	.	.	0	427.42315	0	0	0.15
Day 9	1	1	68		77.02	.	.	.	3209.2139	405.58401	0	0	0.007
Day 11	1	1	68		77.02	.	.	.	0	530.37909	0	153	0
Day 13	1	1	68			.	.	.	0	720.69159	0	28	0
Day 15	1	1	68			-404	9.09	8.84	34331.5	620.85552	0	0	0
Day 0	0	2	42	165.155	82.125	-169.2	6.06	6.6	.	.	.	.	.
Day 1	0	2	42			.	.	.	.	.	.	.	.
Day 2	0	2	42			.	.	.	3704.1859	781.84118	0	0	.
Day 3	0	2	42		82.125	.	.	.	1831.8192	0	0	50	0.47
Day 4	0	2	42			.	.	.	2275.1962	371.26536	0	62	0.4
Day 5	0	2	42		82.125	.	.	.	2063.0522	374.38524	0	1	0.28
Day 6	0	2	42			.	.	.	4210.2443	331.45573	0	38	0.3
Day 7	0	2	42		82.155	.	.	.	0	385.30481	0	0	0.18
Day 9	0	2	42		82.155	.	.	.	23149.615	602.13626	0	0	0.007
Day 11	0	2	42		82.155	.	.	.	0	483.58094	0	0	0
Day 13	0	2	42			.	.	.	0	536.61884	0	0	0
Day 15	0	2	42			-418	7.88	8.7	5479.2461	717.57171	0	0	0

Day	Treatment	Period	Bunk	Feces (g)	Urine (g)	ORP mv	EC ms/cm	pH	CO_2 ppm	N_2O ppb	CH_4 ppm	NH_3 ppm	H_2S ppm
Day 0	0	2	59	107.664	52.232	-87.9	13.34	6.26	.	.	.	.	.
Day 1	0	2	59			.	.	.	.	.	.	.	.
Day 2	0	2	59			.	.	.	5077.0257	349.42622	0	132	.
Day 3	0	2	59		52.232	.	.	.	3345.6286	355.66598	0	251	2.4
Day 4	0	2	59			.	.	.	7668.668	455.50204	0	601	3.7
Day 5	0	2	59		52.232	.	.	.	2076.6053	424.30327	0	264	1.8
Day 6	0	2	59			.	.	.	2452.0955	324.46721	0	426	1.5
Day 7	0	2	59		52.232	.	.	.	0	389.98463	0	216	0.19
Day 9	0	2	59		52.232	.	.	.	23026.55	558.45798	0	359	0.003
Day 11	0	2	59		52.232	.	.	.	0	0	0	601	0.023
Day 13	0	2	59			.	.	.	0	368.14549	0	369	0
Day 15	0	2	59			-499	24.8	9.18	1857.3878	0	0	261	0
Day 0	1	2	58	126.908	63.613	-170.9	11.71	7.29	.	.	.	.	.
Day 1	1	2	58			.	.	.	.	.	.	.	.
Day 2	1	2	58			.	.	.	3315.5603	683.25306	0	43	.
Day 3	1	2	58		63.613	.	.	.	5024.5032	368.14549	0	64	0.43
Day 4	1	2	58			.	.	.	4388.8671	389.98463	0	109	1.2
Day 5	1	2	58		63.613	.	.	.	3609.3871	396.84835	0	72	0.28
Day 6	1	2	58			.	.	.	3679.5369	330.70696	0	94	0.23
Day 7	1	2	58		63.613	.	.	.	4181.9872	352.5461	0	24	0.11
Day 9	1	2	58		63.613	.	.	.	2363.8717	430.54303	0	29	0.005
Day 11	1	2	58		63.613	.	.	.	7291.6968	0	0	55	0
Day 13	1	2	58			.	.	.	0	386.86475	0	17	0
Day 15	1	2	58			-461	13.8	9.04	15344.763	464.86167	0	0	0

ay	Treatment	Period	Bunk	Feces (g)	Urine (g)	ORP mv	EC ms/cm	pH	CO_2 ppm	N_2O ppb	CH_4 ppm	NH_3 ppm	H_2S ppm
Day 0	1	2	63	87.167	44.54	-66.4	8.66	6.29	.	.	.	.	.
Day 1	1	2	63			.	.	.	.	.	.	.	.
Day 2	1	2	63			.	.	.	2617.2189	386.86475	0	22	.
Day 3	1	2	63		44.54	.	.	.	1373.3836	492.94057	0	26	0.15
Day 4	1	2	63			.	.	.	60.131848	346.30635	0	21	0.29
Day 5	1	2	63		44.54	.	.	.	729.51688	418.06352	0	6	0.29
Day 6	1	2	63			.	.	.	0	59.277663	0	36	0.2
Day 7	1	2	63		44.54	.	.	.	4109.7688	430.54303	0	0	0.039
Day 9	1	2	63		44.54	.	.	.	0	355.66598	0	0	0.001
Day 11	1	2	63		44.54	.	.	.	8139.802	418.06352	0	64	0
Day 13	1	2	63			.	.	.	0	343.18647	0	0	0
Day 15	1	2	63			-357	6.23	8.97	16878.377	0	0	0	0
Day 0	0.5	2	54	225.329	122.816	-113.1	7.08	6.43	.	.	.	.	.
Day 1	0.5	2	54			.	.	.	.	.	.	.	.
Day 2	0.5	2	54			.	.	.	758.52662	365.02561	0	29	.
Day 3	0.5	2	54		122.816	.	.	.	1369.897	362.8417	0	78	0.38
Day 4	0.5	2	54			.	.	.	822.75694	408.70389	0	21	0.48
Day 5	0.5	2	54		122.816	.	.	.	1356.2905	336.94672	0	34	1.1
Day 6	0.5	2	54			.	.	.	6972.5847	414.94364	0	0	2
Day 7	0.5	2	54		122.816	.	.	.	0	380.62499	0	63	0.11
Day 9	0.5	2	54		122.816	.	.	.	6721.5295	349.42622	0	26	0.004
Day 11	0.5	2	54		122.816	.	.	.	496.37061	402.46413	0	148	0
Day 13	0.5	2	54			.	.	.	0	402.46413	0	88	0
Day 15	0.5	2	54			-390	13.98	9.11	5996.5175	330.70696	0	91	0

Treatment	Period	Bunk	Feces (g)	Urine (g)	ORP mv	EC ms/cm	pH	CO_2 ppm	N_2O ppm	CH_4 ppb	NH_3 ppm	H_2S ppm	H_2S ppm
Day 0	0	1	52	126.082	63.014	-185.7	8.57	6.78	.	.	.	.	.
Day 1	0	1	52			.	.	.	.	.	.	.	.
Day 2	0	1	52			.	.	.	5096.082	0	0	0	.
Day 3	0	1	52		63.014	.	.	.	4522.1022	0	0	0	0
Day 4	0	1	52			.	.	.	2816.2558	344.12243	0	15	0
Day 5	0	1	52		63.014	.	.	.	2153.9568	417.81393	0	19	0
Day 6	0	1	52			.	.	.	2203.1933	427.42315	0	198	0
Day 7	0	1	52		63.014	.	.	.	2069.0859	403.1817	0	90	0
Day 9	0	1	52		63.014	.	.	.	3199.4199	427.42315	0	86	0
Day 11	0	1	52		63.014	.	.	.	2177.9045	402.46413	0	169	0
Day 13	0	1	52			.	.	.	2107.4023	371.26536	0	396	2.2
Day 15	0	1	52			-431	44.4	8.9	2543.2514	405.58401	0	106	4.9
Day 0	0.5	2	43	132.046	66.019	-113.3	9.26	6.03	.	.	.	.	.
Day 1	0.5	2	43			.	.	.	.	.	.	.	.
Day 2	0.5	2	43			.	.	.	46726.857	0	0	0	0
Day 3	0.5	2	43		66.019	.	.	.	1456.0234	0	0	0	0
Day 4	0.5	2	43			.	.	.	23890.279	717.57171	0	0	0
Day 5	0.5	2	43		66.019	.	.	.	37607.552	653.33344	0	12	0
Day 6	0.5	2	43			.	.	.	6226.416	477.34118	0	0	0
Day 7	0.5	2	43		66.019	.	.	.	10422.062	458.62192	0	0	0
Day 9	0.5	2	43		66.019	.	.	.	5536.7207	318.22745	0	15	0
Day 11	0.5	2	43		66.019	.	.	.	7069.3769	414.94364	0	44	0
Day 13	0.5	2	43			.	.	.	5594.1953	399.34426	0	84	0.22
Day 15	0.5	2	43			-443	9.16	8.67	7797.3886	324.81039	0	10	1.9

Day	Treatment	Period	Bunk	Feces (g)	Urine (g)	ORP mv	EC ms/cm	pH	CO_2 ppm	N_2O ppb	CH_4 ppm	NH_3 ppm	H_2S ppm
Day 0	0.5	2	57	105.332	52.667	-250	10.02	7.93	.	.	.	.	.
Day 1	0.5	2	57			.	.	.	.	.	.	.	.
Day 2	0.5	2	57			.	.	.	4866.1836	358.53626	0	0	0
Day 3	0.5	2	57		52.667	.	.	.	2532.5229	511.59743	0	0	0
Day 4	0.5	2	57			.	.	.	53977.854	550.62709	0	18	0
Day 5	0.5	2	57		52.667	.	.	.	7661.557	601.85547	0	16	0
Day 6	0.5	2	57			.	.	.	0	0	0	59	0
Day 7	0.5	2	57		52.667	.	.	.	31398.187	0	0	37	0
Day 9	0.5	2	57		52.667	.	.	.	6091.1591	359.90901	0	25	0
Day 11	0.5	2	57		52.667	.	.	.	8246.4569	412.51014	0	89	0
Day 13	0.5	2	57			.	.	.	19149.965	507.88478	0	154	1.1
Day 15	0.5	2	57			-429	8.75	9.02	8949.3714	489.6335	0	21	2.3
Day 0	0.5	1	64	106.906	53.453	-144	7.03	6.2	.	.	.	.	.
Day 1	0.5	1	64			.	.	.	.	.	.	.	.
Day 2	0.5	1	64			.	.	.	1948.0061	0	0	0	0
Day 3	0.5	1	64		53.453	.	.	.	7431.6585	408.92228	0	0	0
Day 4	0.5	1	64			.	.	.	7695.2754	416.84677	0	37	0
Day 5	0.5	1	64		53.453	.	.	.	7776.8893	355.63478	0	40	0
Day 6	0.5	1	64			.	.	.	3123.5534	0	0	107	0
Day 7	0.5	1	64		53.453	.	.	.	5538.4449	350.45578	0	138	0
Day 9	0.5	1	64		53.453	.	.	.	4147.9425	384.49364	0	11	0
Day 11	0.5	1	64		53.453	.	.	.	3419.3561	429.41987	0	87	0
Day 13	0.5	1	64			.	.	.	3600.9758	399.46905	0	121	1.4
Day 15	0.5	1	64			-325	6.56	8.92	1574.038	317.0731	0	15	2.8

Day	Treatment	Period	Bunk	Feces (g)	Urine (g)	ORP mv	EC ms/cm	pH	CO_2 ppm	N_2O ppb	CH_4 ppm	NH_3 ppm	H_2S ppm
Day 0	1	1	49	72.368	36.34	-98.6	7.54	6.38	.	.	.	.	.
Day 1	1	1	49			.	.	.	.	.	.	.	.
Day 2	1	1	49			.	.	.	17563.857	375.60199	0	0	0
Day 3	1	1	49		36.34	.	.	.	1617.1439	0	0	0	0
Day 4	1	1	49			.	.	.	6330.2534	396.75476	0	0	0
Day 5	1	1	49		36.34	.	.	.	2080.5808	0	0	13	0
Day 6	1	1	49			.	.	.	4808.9005	457.31157	0	23	0
Day 7	1	1	49		36.34	.	.	.	5368.5116	918.1174	0	12	0
Day 9	1	1	49		36.34	.	.	.	6496.7382	534.49733	0	35	0
Day 11	1	1	49		36.34	.	.	.	1417.8986	0	0	22	0
Day 13	1	1	49			.	.	.	4586.0906	464.98647	0	94	0.25
Day 15	1	1	49			-400	8.24	8.86	3308.2385	311.36372	0	4	2
Day 0	1	2	67	62.226	31.113	-139.4	8.85	6.65	.	.	.	.	.
Day 1	1	2	67			.	.	.	.	.	.	.	.
Day 2	1	2	67			.	.	.	42703.634	440.40184	0	0	0
Day 3	1	2	67		31.133	.	.	.	6182.3521	365.43119	0	0	0
Day 4	1	2	67			.	.	.	15931.77	425.36403	0	75	0
Day 5	1	2	67		31.133	.	.	.	8347.229	307.86946	0	39	0
Day 6	1	2	67			.	.	.	1831.7158	0	0	190	0
Day 7	1	2	67		31.133	.	.	.	7589.3305	486.29523	0	144	0
Day 9	1	2	67		31.133	.	.	.	5310.4623	376.53796	0	139	0
Day 11	1	2	67		31.133	.	.	.	4731.8846	389.85983	0	260	0
Day 13	1	2	67			.	.	.	7771.525	376.03877	0	338	1.9
Day 15	1	2	67			-399	16.57	9.09	7107.5017	347.83509	0	58	4.8

Day	Treatment	Period	Bunk	Feces (g)	Urine (g)	ORP mv	EC ms/cm	pH	CO_2 ppm	N_2O ppb	CH_4 ppm	NH_3 ppm	H_2S ppm
Day 0	1	1	51	105.501	52.514	-85.1	6.25	6.52	.	.	.	.	.
Day 1	1	1	51			.	.	.	.	.	.	.	.
Day 2	1	1	51			.	.	.	8458.9214	439.12269	0	0	0
Day 3	1	1	51		52.514	.	.	.	5427.9021	389.14226	0	0	0
Day 4	1	1	51			.	.	.	5748.9936	412.79093	0	0	0
Day 5	1	1	51		52.514	.	.	.	14452.565	334.54441	0	0	0
Day 6	1	1	51			.	.	.	5976.4014	332.42289	0	0	0
Day 7	1	1	51		52.514	.	.	.	7631.0954	484.4233	0	0	0
Day 9	1	1	51		52.514	.	.	.	7066.3116	450.19825	0	0	0
Day 11	1	1	51		52.514	.	.	.	1934.2122	0	0	0	0
Day 13	1	1	51			.	.	.	7241.226	390.10942	0	0	0.18
Day 15	1	1	51			-426	3.2	8.52	6920.1345	425.89441	0	0	0.45
Day 0	0.5	2	44	157.504	78.752	-153.6	5.75	6.48	.	.	.	.	.
Day 1	0.5	2	44			.	.	.	.	.	.	.	.
Day 2	0.5	2	44			.	.	.	7679.5657	418.74989	0	0	0
Day 3	0.5	2	44		78.752	.	.	.	16169.906	441.55619	0	0	0
Day 4	0.5	2	44			.	.	.	16739.863	339.25542	0	5	0
Day 5	0.5	2	44		78.752	.	.	.	21732.682	585.13293	0	0	0
Day 6	0.5	2	44			.	.	.	3121.8292	451.66459	0	80	0
Day 7	0.5	2	44		78.752	.	.	.	21537.843	1581.7152	0	39	0
Day 9	0.5	2	44		78.752	.	.	.	17544.124	389.42305	0	44	0
Day 11	0.5	2	44		78.752	.	.	.	5530.2069	348.52146	0	90	0
Day 13	0.5	2	44			.	.	.	3607.298	400.59221	0	102	1.5
Day 15	0.5	2	44			-433	8.22	8.82	1434.1831	0	0	11	3.2

Day	Treatment	Period	Bunk	Feces (g)	Urine (g)	ORP mv	EC ms/cm	pH	CO_2 ppm	N_2O ppb	CH_4 ppm	NH_3 ppm	H_2S ppm
Day 0	0.5	2	66	88.95	44.475	-151.8	5.91	6.54	.	.	.	.	.
Day 1	0.5	2	66			.	.	.	.	.	.	.	.
Day 2	0.5	2	66			.	.	.	2049.1614	0	0	0	0
Day 3	0.5	2	66		44.475	.	.	.	7081.0634	400.717	0	0	0
Day 4	0.5	2	66			.	.	.	8749.7429	343.81045	0	1	0
Day 5	0.5	2	66		44.475	.	.	.	40935.716	361.37535	0	0	0
Day 6	0.5	2	66			.	.	.	4866.1836	358.69226	0	30	0
Day 7	0.5	2	66		44.475	.	.	.	6805.1853	426.45599	0	0	0
Day 9	0.5	2	66		44.475	.	.	.	8896.8779	510.75506	0	16	0
Day 11	0.5	2	66		44.475	.	.	.	5502.8106	411.76137	0	10	0
Day 13	0.5	2	66			.	.	.	7563.0838	604.94415	0	36	0.33
Day 15	0.5	2	66			-379	4.18	9.01	2656.2848	0	0	1	1.5
Day 0	0.5	1	53	107.017	51.5085	-74.4	7.09	6.76	.	.	.	.	.
Day 1	0.5	1	53			.	.	.	.	.	.	.	.
Day 2	0.5	1	53			.	.	.	19380.438	356.28995	0	0	0
Day 3	0.5	1	53		51.508	.	.	.	39562.839	427.76634	0	0	0
Day 4	0.5	1	53			.	.	.	6020.2737	369.89262	0	0	0
Day 5	0.5	1	53		51.509	.	.	.	29130.814	427.07996	0	51	0
Day 6	0.5	1	53			.	.	.	5014.4681	778.93969	0	56	0
Day 7	0.5	1	53		51.508	.	.	.	1849.3413	448.60711	0	7	0
Day 9	0.5	1	53		51.508	.	.	.	8814.8808	479.21311	0	18	0
Day 11	0.5	1	53		51.508	.	.	.	4392.5928	373.94846	0	39	0
Day 13	0.5	1	53			.	.	.	3443.4954	394.32125	0	15	0.52
Day 15	0.5	1	53			-394	7.38	8.74	3355.9424	378.62827	0	0	2.1

Day	Treatment	Period	Bunk	Feces (g)	Urine (g)	ORP mv	EC ms/cm	pH	CO_2 ppm	N_2O ppb	CH_4 ppm	NH_3 ppm	H_2S ppm
Day 1	1	2	68			.	.	.	.	.	.	.	.
Day 2	1	2	68			.	.	.	11049.302	383.21449	0	0	0
Day 3	1	2	68		39.328	.	.	.	13538.144	400.24902	0	0	0
Day 4	1	2	68			.	.	.	1542.2353	0	0	27	0
Day 5	1	2	68		39.328	.	.	.	9063.7458	0	0	31	0.0001
Day 6	1	2	68			.	.	.	11739.189	408.3607	0	224	0
Day 7	1	2	68		39.328	.	.	.	1962.7579	361.21936	0	105	0
Day 9	1	2	68		39.328	.	.	.	12489.999	864.73631	0	111	0
Day 11	1	2	68		39.328	.	.	.	5493.2315	471.44461	0	80	0
Day 13	1	2	68			.	.	.	5598.0269	393.35409	0	80	0.23
Day 15	1	2	68			-307	8.61	9.08	13253.645	914.40475	0	0	2
Day 0	0	2	62	124.901	62.767	-121.3	2.68	6.63	.	.	.	.	.
Day 1	0	2	62			.	.	.	.	.	.	.	.
Day 2	0	2	62			.	.	.	41791.896	348.86465	0	0	0
Day 3	0	2	62		62.767	.	.	.	1602.2005	0	0	0	0
Day 4	0	2	62			.	.	.	2931.5882	0	0	0	0
Day 5	0	2	62		62.767	.	.	.	9936.402	383.62008	0	15	0
Day 6	0	2	62			.	.	.	4393.1675	0	0	5	0
Day 7	0	2	62		62.767	.	.	.	7267.4727	702.78349	0	0	0
Day 9	0	2	62		62.767	.	.	.	4954.886	0	0	16	0
Day 11	0	2	62		62.767	.	.	.	5902.0676	368.61347	0	0	0
Day 13	0	2	62			.	.	.	17274.185	424.42807	0	0	0.48
Day 15	0	2	62			-444	7.56	9	2500.9118	379.59543	0	23	3.2

Day	Treatment	Period	Bunk	Feces (g)	Urine (g)	ORP mv	EC ms/cm	pH	CO_2 ppm	N_2O ppb	CH_4 ppm	NH_3 ppm	H_2S ppm
Day 0	0	1	59	92.259	48.516	-107.4	6.74	6.4	.	.	.	.	.
Day 1	0	1	59			.	.	.	.	.	.	.	.
Day 2	0	1	59			.	.	.	13778.388	0	0	0	0
Day 3	0	1	59		48.516	.	.	.	6996.001	0	0	0	0
Day 4	0	1	59			.	.	.	2019.4662	0	0	43	0
Day 5	0	1	59		48.516	.	.	.	9005.6965	381.46736	0	123	0
Day 6	0	1	59			.	.	.	29061.27	347.83509	0	234	0
Day 7	0	1	59		48.516	.	.	.	32060.87	925.94829	0	102	0
Day 9	0	1	59		48.516	.	.	.	8496.663	428.45271	0	153	0
Day 11	0	1	59		48.516	.	.	.	12511.648	578.61239	0	201	0
Day 13	0	1	59			.	.	.	26078.529	1428.9661	0	164	2.2
Day 15	0	1	59			-445	13.63	9.09	3701.9396	364.93201	0	68	5.8
Day 0	0.5	1	61	120.881	60.44	-138.7	7.79	6.62	.	.	.	.	.
Day 1	0.5	1	61			.	.	.	.	.	.	.	.
Day 2	0.5	1	61			.	.	.	9707.653	359.47223	0	0	0
Day 3	0.5	1	61		60.44	.	.	.	3915.3619	352.23411	0	0	0
Day 4	0.5	1	61			.	.	.	2009.3123	0	0	0	0
Day 5	0.5	1	61		60.44	.	.	.	12395.549	470.50865	0	136	0
Day 6	0.5	1	61			.	.	.	2169.0917	0	0	244	0
Day 7	0.5	1	61		60.44	.	.	.	11334.951	397.84672	0	117	0
Day 9	0.5	1	61		60.44	.	.	.	11696.466	550.97028	0	154	0
Day 11	0.5	1	61		60.44	.	.	.	10567.856	498.40035	0	73	0
Day 13	0.5	1	61			.	.	.	5116.1981	358.41147	0	36	1.3
Day 15	0.5	1	61			-376	8.03	9.15	4201.5855	351.79733	0	21	3.8

Day	Treatment	Period	Bunk	Feces (g)	Urine (g)	ORP mv	EC ms/cm	pH	CO_2 ppm	N_2O ppb	CH_4 ppm	NH_3 ppm	H_2S ppm
Day 0	0.5	2	64	125.628	62.814	-175.8	6.71	6.78	.	.	.	.	.
Day 1	0.5	2	64			.	.	.	.	.	.	.	.
Day 2	0.5	2	64			.	.	.	21175.562	0	0	0	0
Day 3	0.5	2	64		62.814	.	.	.	8565.2494	395.28842	0	0	0
Day 4	0.5	2	64			.	.	.	5724.2795	318.19626	0	41	0
Day 5	0.5	2	64		62.814	.	.	.	3882.793	0	0	137	0
Day 6	0.5	2	64			.	.	.	8077.6731	423.86649	0	224	0
Day 7	0.5	2	64		62.814	.	.	.	6549.0401	382.37213	0	59	0
Day 9	0.5	2	64			.	.	.	4174.1893	389.26705	0	205	0
Day 11	0.5	2	64		62.814	.	.	.	7545.8414	369.70542	0	0	0
Day 13	0.5	2	64			.	.	.	6116.0647	357.91229	0	67	1.8
Day 15	0.5	2	64			-449	15.21	9.02	4311.5536	350.23739	0	139	5.8
Day 0	1	1	67	195.998	97.999	-185.6	7.01	6.73	.	.	.	.	.
Day 1	1	1	67			.	.	.	.	.	.	.	.
Day 2	1	1	67			.	.	.	4249.6726	373.23089	0	0	0
Day 3	1	1	67		97.999	.	.	.	32042.095	396.97315	0	0	0
Day 4	1	1	67			.	.	.	12305.314	337.57069	0	0	0
Day 5	1	1	67		97.999	.	.	.	6608.6221	0	0	20	0
Day 6	1	1	67			.	.	.	8007.7457	359.12904	0	34	0
Day 7	1	1	67		97.999	.	.	.	25457.037	1852.1462	0	0	0
Day 9	1	1	67		97.999	.	.	.	6191.9312	434.72366	0	41	0
Day 11	1	1	67		97.999	.	.	.	8192.0476	457.65476	0	88	0
Day 13	1	1	67			.	.	.	12529.273	457.21797	0	0	1.9
Day 15	1	1	67			-356	9.23	8.19	4187.6	353.73165	0	0	3.8

Day	Treatment	Period	Bunk	Feces (g)	Urine (g)	ORP mv	EC ms/cm	pH	CO_2 ppm	N_2O ppb	CH_4 ppm	NH_3 ppm	H_2S ppm
Day 1	1	1	69			.	.	.	.	.	.	.	.
Day 2	1	1	69			.	.	.	19590.22	0	0	0	0
Day 3	1	1	69		58.915	.	.	.	13870.156	378.78427	0	0	0
Day 4	1	1	69			.	.	.	4226.4912	397.65952	0	0	0
Day 5	1	1	69		58.915	.	.	.	1661.2078	0	0	68	0
Day 6	1	1	69			.	.	.	9771.6414	313.82843	0	36	0
Day 7	1	1	69		58.914	.	.	.	58353.971	629.96556	0	18	0
Day 9	1	1	69		58.915	.	.	.	7925.9402	557.67801	0	57	0
Day 11	1	1	69		58.914	.	.	.	5512.7729	397.16034	0	52	0
Day 13	1	1	69			.	.	.	18482.493	0	0	0	1.3
Day 15	1	1	69			-361	8.96	8.07	39816.11	434.38047	0	0	6.4
Day 0	0.5	1	57	145.596	72.798	-198.5	7.74	6.78	.	.	.	.	.
Day 1	0.5	1	57			.	.	.	.	.	.	.	.
Day 2	0.5	1	57			.	.	.	4680.5406	329.92699	0	0	0
Day 3	0.5	1	57		72.798	.	.	.	5207.1996	410.8878	0	0	0
Day 4	0.5	1	57			.	.	.	5173.8643	357.22592	0	21	0
Day 5	0.5	1	57		72.798	.	.	.	4218.6363	319.75619	0	33	0
Day 6	0.5	1	57			.	.	.	5615.0777	362.87289	0	144	0
Day 7	0.5	1	57		72.798	.	.	.	2542.2935	310.92694	0	86	0
Day 9	0.5	1	57		72.798	.	.	.	7642.2072	726.83774	0	41	0
Day 11	0.5	1	57		72.798	.	.	.	7143.7107	726.77535	0	80	0
Day 13	0.5	1	57			.	.	.	14710.243	3662.9228	0	60	1.3
Day 15	0.5	1	57						38238.624	9638.2672	0	24	3.3

Day	Treatment	Period	Bunk	Feces (g)	Urine (g)	ORP mv	EC ms/cm	pH	CO_2 ppm	N_2O ppb	CH_4 ppm	NH_3 ppm	H_2S ppm
Day 0	blank	blank	2A			.	.	.	.	.	.	.	.
Day 1	blank	blank	2A			.	.	.	.	.	.	.	.
Day 2	blank	blank	2A			.	.	.	2666.2471	383.24569	0	0	0
Day 3	blank	blank	2A			.	.	.	2840.9699	410.8878	0	0	0
Day 4	blank	blank	2A			.	.	.	2562.4097	355.0108	0	0	0
Day 5	blank	blank	2A			.	.	.	2659.9249	380.25061	0	0	0
Day 6	blank	blank	2A			.	.	.	2344.0061	314.4836	0	0	0
Day 7	blank	blank	2A			.	.	.	2349.9452	387.51992	0	0	0
Day 9	blank	blank	2A			.	.	.	2330.5954	316.51152	0	0	0
Day 11	blank	blank	2A			.	.	.	2154.1483	323.00087	0	0	0
Day 13	blank	blank	2A			.	.	.	3612.2792	0	0	0	0
Day 15	blank	blank	2A			.	.	.	3920.3431	1444.8462	0	0	0.35
Day 0	blank	blank	2B			.	.	.	.	.	.	.	.
Day 1	blank	blank	2B			.	.	.	.	.	.	.	.
Day 2	blank	blank	2B			.	.	.	2699.0076	411.60537	0	0	0
Day 3	blank	blank	2B			.	.	.	0	0	0	0	0
Day 4	blank	blank	2B			.	.	.	2747.6695	385.74159	0	0	0
Day 5	blank	blank	2B			.	.	.	2667.205	427.64154	0	0	0
Day 6	blank	blank	2B			.	.	.	0	367.7087	0	0	0
Day 7	blank	blank	2B			.	.	.	1379.199	428.01593	0	0	0
Day 9	blank	blank	2B			.	.	.	1666.1889	387.83191	0	0	0
Day 11	blank	blank	2B			.	.	.	2159.5126	362.21772	0	0	0
Day 13	blank	blank	2B			.	.	.	1397.3993	0	0	0	0
Day 15	blank	blank	2B			.	.	.	2329.8291	436.47079	0	0	0.39

Day	Treatment	Period	Bunk	Feces (g)	Urine (g)	ORP mv	EC ms/cm	pH	CO_2 ppm	N_2O ppb	CH_4 ppm	NH_3 ppm	H_2S ppm
Day 0	blank	blank	3A			.	.	.	.	.	.	.	.
Day 1	blank	blank	3A			.	.	.	.	.	.	.	.
Day 2	blank	blank	3A			.	.	.	2602.6419	390.35901	0	0	0.023
Day 3	blank	blank	3A			.	.	.	2132.308	416.44118	0	0	0.34
Day 4	blank	blank	3A			.	.	.	3735.2748	338.28826	0	0	0.19
Day 5	blank	blank	3A			.	.	.	2063.3385	0	0	0	0.11
Day 6	blank	blank	3A			.	.	.	1848.0003	0	0	0	0.28
Day 7	blank	blank	3A			.	.	.	1843.0191	312.73647	0	0	0.54
Day 9	blank	blank	3A			.	.	.	2033.2601	567.19364	0	0	0.1
Day 11	blank	blank	3A			.	.	.	1788.6098	0	0	0	0.12
Day 13	blank	blank	3A			.	.	.	1930.9553	446.3608	0	0	0.54
Day 15	blank	blank	3A			.	.	.	1770.0264	0	0	0	0.53
Day 0	0.5	2	61	133.654	66.827	-150.7	3.69	6.65	.	.	.	.	.
Day 1	0.5	2	61			.	.	.	.	.	.	.	.
Day 2	0.5	2	61			.	.	.	2094.7579	615.11495	0	0	0.32
Day 3	0.5	2	61		66.827	.	.	.	2162.0032	870.97606	0	59	1.6
Day 4	0.5	2	61			.	.	.	5705.3129	397.06675	0	56	2
Day 5	0.5	2	61		66.827	.	.	.	2007.0133	453.53652	0	0	1.3
Day 6	0.5	2	61			.	.	.	1836.6969	394.66444	0	68	3.9
Day 7	0.5	2	61		66.827	.	.	.	1911.7971	478.21475	0	62	3.4
Day 9	0.5	2	61		66.827	.	.	.	1756.9988	0	0	87	2.6
Day 11	0.5	2	61		66.827	.	.	.	1765.2368	357.35071	0	134	2.8
Day 13	0.5	2	61			.	.	.	1797.231	490.10148	0	140	5.7
Day 15	0.5	2	61			-427	-15.36	8.83	1863.1352	0	0	156	4.5

Day	Treatment	Period	Bunk	Feces (g)	Urine (g)	ORP mv	EC ms/cm	pH	CO_2 ppm	N_2O ppb	CH_4 ppm	NH_3 ppm	H_2S ppm
Day 0	1	2	69	120.561	60.208	-153.2	8.75	7.04	.	.	.	.	.
Day 1	1	2	69			.	.	.	.	.	.	.	.
Day 2	1	2	69			.	.	.	36873.793	542.39062	0	0	0.043
Day 3	1	2	69		60.208	.	.	.	7248.6977	338.13227	0	38	1.3
Day 4	1	2	69			.	.	.	6147.2926	345.61997	0	40	1.4
Day 5	1	2	69		60.208	.	.	.	11131.299	985.94353	0	0	0.52
Day 6	1	2	69			.	.	.	2830.2413	534.40373	0	65	4.1
Day 7	1	2	69		60.208	.	.	.	2254.7289	433.7253	0	18	3.2
Day 9	1	2	69		60.208	.	.	.	4842.8106	464.1441	0	90	3.3
Day 11	1	2	69		60.208	.	.	.	4644.7147	433.8501	0	68	2.5
Day 13	1	2	69			.	.	.	1648.755	0	0	88	6.9
Day 15	1	2	69			-337	12.49	8.88	2016.4009	0	0	78	4.4
Day 0	0	2	65	113.565	57.78	-132.9	7.52	6.78	.	.	.	.	.
Day 1	0	2	65			.	.	.	.	.	.	.	.
Day 2	0	2	65			.	.	.	38090.339	515.40368	0	0	0.21
Day 3	0	2	65		57.78	.	.	.	4260.9759	407.54953	0	0	1.3
Day 4	0	2	65			.	.	.	6564.1751	334.48201	0	69	2.5
Day 5	0	2	65		57.78	.	.	.	14672.693	377.31792	0	4	1.3
Day 6	0	2	65			.	.	.	1429.5851	0	0	33	3.1
Day 7	0	2	65		57.78	.	.	.	11053.134	465.61044	0	10	3.6
Day 9	0	2	65		57.78	.	.	.	5076.9238	545.10491	0	33	2.4
Day 11	0	2	65		57.78	.	.	.	6103.4203	445.51844	0	20	2.1
Day 13	0	2	65			.	.	.	6555.3623	363.37207	0	81	7.4
Day 15	0	2	65			-476	13.2	9.01	4738.7815	0	0	90	4.8

Day	Treatment	Period	Bunk	Feces (g)	Urine (g)	ORP mv	EC ms/cm	pH	CO_2 ppm	N_2O ppb	CH_4 ppm	NH_3 ppm	H_2S ppm
Day 0	0	2	41	102.206	51.1025	-132.5	3.21	6.33	.	.	.	.	.
Day 1	0	2	41			.	.	.	.	.	.	.	.
Day 2	0	2	41			.	.	.	11466.951	427.36075	0	0	0.49
Day 3	0	2	41		51.1025	.	.	.	20188.148	440.37064	0	0	0.77
Day 4	0	2	41			.	.	.	6455.1649	426.92397	0	9	1.2
Day 5	0	2	41		51.1025	.	.	.	7190.0736	378.31629	0	0	0.54
Day 6	0	2	41			.	.	.	5431.3506	402.80732	0	0	2.3
Day 7	0	2	41		51.1025	.	.	.	8669.2784	429.41987	0	0	2.5
Day 9	0	2	41		51.1025	.	.	.	8224.425	361.81214	0	11	1.7
Day 11	0	2	41		51.1025	.	.	.	8840.9359	361.81214	0	2	1.3
Day 13	0	2	41			.	.	.	3242.7174	371.14057	0	0	4.1
Day 15	0	2	41			-340	6.53	9.05	3275.6695	355.72838	0	13	4.9
Day 0	1	1	58	110.155	55.0775	-175	7.3	6.8	.	.	.	.	.
Day 1	1	1	58			.	.	.	.	.	.	.	.
Day 2	1	1	58			.	.	.	7199.2695	372.66931	0	0	0.24
Day 3	1	1	58		55.078	.	.	.	8854.7298	424.14728	0	71	3.1
Day 4	1	1	58			.	.	.	4562.9092	408.79748	0	29	2.2
Day 5	1	1	58		55.078	.	.	.	4795.1066	368.48867	0	0	1.2
Day 6	1	1	58			.	.	.	3870.3402	336.32274	0	9	2.1
Day 7	1	1	58		55.078	.	.	.	3647.5303	376.69395	0	0	2.4
Day 9	1	1	58		55.078	.	.	.	2881.3937	375.25881	0	61	3
Day 11	1	1	58		55.078	.	.	.	2654.1774	375.25881	0	13	1.9
Day 13	1	1	58			.	.	.	3638.7175	424.42807	0	0	4.2
Day 15	1	1	58			-258	9.47	8.51	3657.8757	400.40501	0	0	1.7

Day	Treatment	Period	Bunk	Feces (g)	Urine (g)	ORP mv	EC ms/cm	pH	CO_2 ppm	N_2O ppb	CH_4 ppm	NH_3 ppm	H_2S ppm
Day 0	0.5	2	53	141.022	70.511	-131.2	8.4	6.74	.	.	.	.	.
Day 1	0.5	2	53			.	.	.	.	.	.	.	.
Day 2	0.5	2	53			.	.	.	27381.862	412.19815	0	0	0.15
Day 3	0.5	2	53		70.511	.	.	.	1474.99	0	0	14	2
Day 4	0.5	2	53			.	.	.	4792.9992	406.42638	0	47	2.5
Day 5	0.5	2	53		70.511	.	.	.	8528.8488	392.29333	0	15	1.5
Day 6	0.5	2	53			.	.	.	16616.867	308.93022	0	84	4.8
Day 7	0.5	2	53		70.511	.	.	.	15721.605	454.97166	0	15	4.9
Day 9	0.5	2	53		70.511	.	.	.	5673.5102	450.26065	0	65	3.6
Day 11	0.5	2	53		70.511	.	.	.	5641.1329	385.95998	0	91	2.8
Day 13	0.5	2	53			.	.	.	8090.3175	485.79605	0	112	7.9
Day 15	0.5	2	53			.	.	.	12963.781	572.02945	0	94	5
Day 0	0	2	52	88.592	44.296	-145.4	8.02	6.81	.	.	.	.	.
Day 1	0	2	52			.	.	.	.	.	.	.	.
Day 2	0	2	52			.	.	.	7202.718	390.85819	0	116	0.12
Day 3	0	2	52		44.296	.	.	.	1516.7549	0	0	11	2.8
Day 4	0	2	52			.	.	.	4900.0936	362.24892	0	80	3.8
Day 5	0	2	52		44.296	.	.	.	5066.9615	360.65778	0	5	2.2
Day 6	0	2	52			.	.	.	5970.4624	309.05502	0	13	3.1
Day 7	0	2	52		44.296	.	.	.	4851.4317	338.25706	0	0	2.5
Day 9	0	2	52		44.296	.	.	.	1884.0177	0	0	60	2.9
Day 11	0	2	52		44.296	.	.	.	2167.1759	440.52663	0	44	2.3
Day 13	0	2	52			.	.	.	3564.3837	382.24733	0	75	7.3
Day 15	0	2	52			-384	13.72	9.12	2766.2529	350.48698	0	63	6.4

Day	Treatment	Period	Bunk	Feces (g)	Urine (g)	ORP mv	EC ms/cm	pH	CO_2 ppm	N_2O ppb	CH_4 ppm	NH_3 ppm	H_2S ppm
Day 0	1	2	51	150.488	75.244	-97.8	6.49	6.19	.	.	.	.	.
Day 1	1	2	51			.	.	.	.	.	.	.	.
Day 2	1	2	51			.	.	.	5939.2345	387.42633	0	0	0.036
Day 3	1	2	51		75.244	.	.	.	3359.5825	0	0	0	0.48
Day 4	1	2	51			.	.	.	4758.3229	368.64467	0	2	1.1
Day 5	1	2	51		75.244	.	.	.	8388.036	402.96331	0	0	1.5
Day 6	1	2	51			.	.	.	16470.116	335.60517	0	2	2.5
Day 7	1	2	51		75.244	.	.	.	23119.161	353.88765	0	0	2.6
Day 9	1	2	51		75.244	.	.	.	1769.0685	0	0	0	2.3
Day 11	1	2	51		75.244	.	.	.	3787.1936	326.77592	0	0	1.9
Day 13	1	2	51			.	.	.	6003.6061	594.58616	0	0	4
Day 15	1	2	51			-449	6.41	8.6	4512.9063	0	0	0	3.3
Day 0	0.5	1	66	109.821	54.9105	-161	3.17	6.5	.	.	.	.	.
Day 1	0.5	1	66			.	.	.	.	.	.	.	.
Day 2	0.5	1	66			.	.	.	9332.5354	346.33755	0	0	0.21
Day 3	0.5	1	66		54.9105	.	.	.	13744.861	374.26044	0	0	0.65
Day 4	0.5	1	66			.	.	.	6551.1475	387.9879	0	0	0.6
Day 5	0.5	1	66		54.9105	.	.	.	7050.6019	381.09298	0	0	1.2
Day 6	0.5	1	66			.	.	.	4558.5028	381.06178	0	0	1.4
Day 7	0.5	1	66		54.9105	.	.	.	10753.308	460.02586	0	0	2.1
Day 9	0.5	1	66		54.9105	0	.	.	4028.3953	0	0	0	1.2
Day 11	0.5	1	66		54.9105	.	.	.	4721.5391	392.66772	0	0	1.1
Day 13	0.5	1	66			.	.	.	4304.6566	616.70609	0	0	2.5
Day 15	0.5	1	66			-377	3.06	8.48	3492.3488	451.4462	0	0	1.9

Day	Treatment	Period	Bunk	Feces (g)	Urine (g)	ORP mv	EC ms/cm	pH	CO_2 ppm	N_2O ppb	CH_4 ppm	NH_3 ppm	H_2S ppm
Day 0	0	2	47	204.22	102.11	-200	3.32	6.56	.	.	.	.	.
Day 1	0	2	47			.	.	.	.	.	.	11	.
Day 2	0	2	47			.	.	.	10797.18	384.83683	0	32	0.33
Day 3	0	2	47		102.11	.	.	.	7083.9371	383.62008	0	0	4.6
Day 4	0	2	47			.	.	.	3510.9323	376.63155	0	26	4.2
Day 5	0	2	47		102.11	.	.	.	12756.298	342.5001	0	63	2.6
Day 6	0	2	47			.	.	.	4984.7728	387.05194	0	153	8.9
Day 7	0	2	47		102.11	.	.	.	5497.6379	370.92218	0	150	7.2
Day 9	0	2	47		102.11	.	.	.	5368.1285	359.50343	0	128	4.8
Day 11	0	2	47		102.11	.	.	.	2748.819	389.51664	0	211	4.1
Day 13	0	2	47			.	.	.	4795.873	482.45778	0	152	16
Day 15	0	2	47			-478	16.55	9.07	4340.0993	487.44958	0	198	12
Day 0	0.5	1	54	102.442	51.221	-180.9	7.01	6.4	.	.	.	.	.
Day 1	0.5	1	54			.	.	.	.	.	.	.	.
Day 2	0.5	1	54			.	.	.	8887.1072	351.11096	0	0	0.17
Day 3	0.5	1	54		51.221	.	.	.	17764.061	343.03048	0	0	1.4
Day 4	0.5	1	54			.	.	.	5484.6104	349.17663	0	7	2.4
Day 5	0.5	1	54		51.221	.	.	.	5468.5175	341.84492	0	7	2.1
Day 6	0.5	1	54			.	.	.	5125.0109	404.99123	0	32	5.3
Day 7	0.5	1	54		51.221	.	.	.	6278.1431	482.52018	0	7	4.2
Day 9	0.5	1	54		51.221	.	.	.	7182.0271	373.13729	0	0	3.1
Day 11	0.5	1	54		51.221	.	.	.	6204.0009	381.84175	0	0	2.1
Day 13	0.5	1	54			.	.	.	7447.1767	470.19666	0	34	5.3
Day 15	0.5	1	54			-460	7.93	9	5880.9936	394.50845	0	0	3.8

Day	Treatment	Period	Bunk	Feces (g)	Urine (g)	ORP mv	EC ms/cm	pH	CO_2 ppm	N_2O ppb	CH_4 ppm	NH_3 ppm	H_2S ppm
Day 0	0.5	2	48	90.409	45.409	-127.7	6.7	6.53	.	.	.	.	.
Day 1	0.5	2	48			.	.	.	.	.	.	.	.
Day 2	0.5	2	48			.	.	.	7784.9358	358.62986	0	0	0.024
Day 3	0.5	2	48		45.409	.	.	.	12912.82	378.28509	0	0	0.51
Day 4	0.5	2	48			.	.	.	2882.1601	387.58232	0	0	1.1
Day 5	0.5	2	48		45.409	.	.	.	5015.6175	372.38852	0	0	1.6
Day 6	0.5	2	48			.	.	.	1546.6417	0	0	0	2.3
Day 7	0.5	2	48		45.409	.	.	.	5467.9427	521.30025	0	0	2.5
Day 9	0.5	2	48		45.409	.	.	.	2861.6608	0	0	0	2.5
Day 11	0.5	2	48		45.409	.	.	.	2616.4358	383.99446	0	22	2.4
Day 13	0.5	2	48			.	.	.	5059.4898	621.60429	0	0	5.2
Day 15	0.5	2	48			-386	11.14	8.81	2913.9627	357.91229	0	0	3.3
Day 0	1	1	46	101.827	50.91	-67.2	8.59	6.56	.	.	.	.	.
Day 1	1	1	46			.	.	.	.	.	.	.	.
Day 2	1	1	46			.	.	.	12081.929	482.55138	0	17	0.18
Day 3	1	1	46		50.91	.	.	.	6830.091	374.16685	0	22	2.8
Day 4	1	1	46			.	.	.	10852.164	361.99933	0	64	3.1
Day 5	1	1	46		50.91	.	.	.	14393.941	376.91234	0	26	2.1
Day 6	1	1	46			.	.	.	3845.6261	341.40814	0	54	5.9
Day 7	1	1	46		50.91	.	.	.	22923.365	591.65347	0	30	4.8
Day 9	1	1	46		50.91	.	.	.	3344.2559	393.38529	0	49	3.5
Day 11	1	1	46		50.91	.	.	.	2822.1949	375.4772	0	32	2.9
Day 13	1	1	46			.	.	.	3496.7552	414.53806	0	28	7.3
Day 15	1	1	46			-447	11.26	9.04	6139.6293	385.36721	0	27	5.3

Day	Treatment	Period	Bunk	Feces (g)	Urine (g)	ORP mv	EC ms/cm	pH	CO_2 ppm	N_2O ppb	CH_4 ppm	NH_3 ppm	H_2S ppm
Day 0	0.5	1	44	134.25	67.125	-219	6.32	6.71	.	.	.	.	.
Day 1	0.5	1	44			.	.	.	.	.	.	.	.
Day 2	0.5	1	44			.	.	.	7450.6251	386.98954	0	0	0.24
Day 3	0.5	1	44		67.125	.	.	.	5152.7903	342.09451	0	0	2.1
Day 4	0.5	1	44			.	.	.	5161.0283	338.81864	0	0	1.5
Day 5	0.5	1	44		67.125	.	.	.	4552.7554	348.36547	0	0	1.4
Day 6	0.5	1	44			.	.	.	4628.8134	348.98944	0	0	2.8
Day 7	0.5	1	44		67.125	.	.	.	4381.2894	395.97479	0	0	2.2
Day 9	0.5	1	44		67.125	.	.	.	6052.8427	368.33268	0	0	1.8
Day 11	0.5	1	44		67.125	.	.	.	6091.5422	354.57402	0	0	1.5
Day 13	0.5	1	44			.	.	.	5513.9224	395.53801	0	0	3.8
Day 15	0.5	1	44			-339	5.9	8.83	4583.9832	382.24733	0	0	2.4
Day 0	0	2	45	79.37	39.685	-203	8.17	6.35	.	.	.	.	.
Day 1	0	2	45			.	.	.	.	.	.	.	.
Day 2	0	2	45			.	.	.	6767.252	368.92546	0	0	0.033
Day 3	0	2	45		39.685	.	.	.	19871.463	407.20635	0	0	0.53
Day 4	0	2	45			.	.	.	6157.4464	392.19974	0	0	1.5
Day 5	0	2	45		39.685	.	.	.	5379.4318	348.42786	0	0	1
Day 6	0	2	45			.	.	.	2697.0918	426.98637	0	0	3.8
Day 7	0	2	45		39.685	.	.	.	2385.1963	460.55624	0	0	3.3
Day 9	0	2	45		39.685	.	.	.	1379.3906	0	0	19	3.3
Day 11	0	2	45		39.685	.	.	.	1865.2426	0	0	46	2.5
Day 13	0	2	45			.	.	.	2256.2616	329.24062	0	0	5
Day 15	0	2	45			-384	10.25	8.98	2083.8377	375.13401	0	11	4.2

Day	Treatment	Period	Bunk	Feces (g)	Urine (g)	ORP mv	EC ms/cm	pH	CO_2 ppm	N_2O ppb	CH_4 ppm	NH_3 ppm	H_2S ppm
Day 1	0	1	41			.	.	.	.	.	.	.	.
Day 2	0	1	41			.	.	.	2034.4096	0	0	0	0.028
Day 3	0	1	41		39.685	.	.	.	2618.9264	351.82853	0	0	0.58
Day 4	0	1	41			.	.	.	8285.5396	419.12428	0	0	0.51
Day 5	0	1	41		39.685	.	.	.	9080.2219	1621.0569	0	0	1.1
Day 6	0	1	41			.	.	.	6717.2491	441.02581	0	0	1.6
Day 7	0	1	41		39.685	.	.	.	11931.346	530.34789	0	0	1.5
Day 9	0	1	41		39.685	.	.	.	3670.9033	322.1897	0	0	0.4
Day 11	0	1	41		39.685	.	.	.	1853.173	406.51997	0	0	0.96
Day 13	0	1	41			.	.	.	6684.8718	395.7252	0	0	2.4
Day 15	0	1	41			-440	6	8.51	3499.0542	352.20291	0	0	1.9
Day 0	0	1	45	92.405	46.205	-139.9	3.26	6.62	.	.	.	.	.
Day 1	0	1	45			.	.	.	.	.	.	.	.
Day 2	0	1	45			.	.	.	6479.879	325.80876	0	0	0.04
Day 3	0	1	45		46.205	.	.	.	2643.4488	348.11588	0	0	1.1
Day 4	0	1	45			.	.	.	2550.9147	392.69892	0	0	1.2
Day 5	0	1	45		46.205	.	.	.	9795.7808	512.97018	0	0	0.59
Day 6	0	1	45			.	.	.	2128.2848	404.11767	0	0	2.7
Day 7	0	1	45		46.205	.	.	.	2774.1078	592.21505	0	0	2.3
Day 9	0	1	45		46.205	.	.	.	2051.0772	383.62008	0	0	1.9
Day 11	0	1	45		46.205	.	.	.	4303.8903	338.47546	0	0	1.5
Day 13	0	1	45			.	.	.	2066.2122	364.65122	0	9	5.4
Day 15	0	1	45			-475	9.58	8.84	1944.366	354.10604	0	0	4

Day	Treatment	Period	Bunk	Feces (g)	Urine (g)	ORP mv	EC ms/cm	pH	CO_2 ppm	N_2O ppb	CH_4 ppm	NH_3 ppm	H_2S ppm
Day 0	blank	blank	3B			.	.	.	.	.	.	.	.
Day 1	blank	blank	3B			.	.	.	.	.	.	.	.
Day 2	blank	blank	3B			.	.	.	8309.679	342.56249	0	0	0.012
Day 3	blank	blank	3B			.	.	.	1715.0423	0	0	0	0
Day 4	blank	blank	3B			.	.	.	4707.5536	377.78591	0	0	0.3
Day 5	blank	blank	3B			.	.	.	2049.9277	0	0	0	0.53
Day 6	blank	blank	3B			.	.	.	1849.7245	367.55271	0	0	0.48
Day 7	blank	blank	3B			.	.	.	1874.4386	456.78119	0	0	0.41
Day 9	blank	blank	3B			.	.	.	0	440.52663	0	0	0.38
Day 11	blank	blank	3B			.	.	.	1816.3892	360.2834	0	0	0.11
Day 13	blank	blank	3B			.	.	.	1779.9886	426.98637	0	0	0.61
Day 15	blank	blank	3B			.	.	.	1464.6446	0	0	0	0.6
Day 0	1	2	46	137.756	68.878	-142.8	6.49	6.34	.	.	.	.	.
Day 1	1	2	46			.	.	.	.	.	.	.	.
Day 2	1	2	46			.	.	.	2238.8276	406.05199	0	0	0.18
Day 3	1	2	46		68.878	.	.	.	2159.7042	339.38022	0	24	0.3
Day 4	1	2	46			.	.	.	1993.6026	363.06009	0	27	2.7
Day 5	1	2	46		68.878	.	.	.	2441.9046	408.73509	0	0	1.4
Day 6	1	2	46			.	.	.	3853.8641	446.4856	0	76	7.7
Day 7	1	2	46		68.878	.	.	.	3544.4591	613.61741	0	84	6.2
Day 9	1	2	46		68.878	.	.	.	5094.9325	412.72853	0	111	4.5
Day 11	1	2	46		68.878	.	.	.	3305.7479	352.01572	0	108	3.8
Day 13	1	2	46			.	.	.	5049.7191	543.91936	0	145	13
Day 15	1	2	46			-478	14.76	9.27	1666.9552	0	0	101	6.2

Day	Treatment	Period	Bunk	Feces (g)	Urine (g)	ORP mv	EC ms/cm	pH	CO_2 ppm	N_2O ppb	CH_4 ppm	NH_3 ppm	H_2S ppm
Day 0	R1	Room	1			.	.	.	.	.	.	.	.
Day 1	R1	Room	1			.	.	.	.	.	.	.	.
Day 2	R1	Room	1			.	.	.	0	0	0	0	0.002
Day 3	R1	Room	1						0	0	0	0	0.049
Day 4	R1	Room	1			.	.	.	0	0	0	0	0.38
Day 5	R1	Room	1			.	.	.	0	382.15373	0	0	0.028
Day 6	R1	Room	1						0	493.37735	0	0	0.021
Day 7	R1	Room	1			.	.	.	0	452.00778	0	0	0.001
Day 9	R1	Room	1			.	.	.	0	0	0	0	0
Day 11	R1	Room	1						0	0	0	0	0
Day 13	R1	Room	1			.	.	.	0	0	0	0	0
Day 15	R1	Room	1			.	.	.	0	0	0	0	0
Day 0	C1	Cal	1			.	.	.	.	.	.	.	.
Day 1	C1	Cal	1			.	.	.	.	.	.	.	.
Day 2	C1	Cal	1			.	.	.	353806221	0	912752027	0	0
Day 3	C1	Cal	1			.	.	.	272221014	0	655025523	0	0
Day 4	C1	Cal	1			.	.	.	21265369	462.36577	563403219	0	0
Day 5	C1	Cal	1			.	.	.	24936317	0	630822208	0	0
Day 6	C1	Cal	1			.	.	.	33751006	0	804229095	0	0
Day 7	C1	Cal	1			.	.	.	32321804	0	793261500	0	0
Day 9	C1	Cal	1			.	.	.	37191819	566.56966	862797406	0	0
Day 11		Cal	1			.	.	.	23100961	348.05348	561848845	0	0
Day 13	C1	Cal	1			.	.	.	12324.664	614.14779	11943.068	0	0
Day 15	C1	Cal	1			.	.	.	11452.774	0	12285.98	0	0

Day	Treatment	Period	Bunk	ORP mv	EC ms/cm	pH	CO_2 ppm	N_2O ppb	CH_4 ppm	NH_3 ppm	H_2S ppm
Day 0	R2	Room	2	.	.	.	.	.	.	.	.
Day 1	R2	Room	2	.	.	.	.	.	.	.	.
Day 2	R2	Room	2	.	.	.	0	0	0	0	0
Day 3	R2	Room	2	.	.	.	4234.5376	0	0	0	0
Day 4	R2	Room	2	.	.	.	0	0	0	0	0
Day 5	R2	Room	2	.	.	.	2488.0758	0	0	0	0
Day 6	R2	Room	2	.	.	.	0	0	0	0	0
Day 7	R2	Room	2	.	.	.	.	.	.	.	.
Day 9	R2	Room	2	.	.	.	.	.	.	.	.
Day 11	R2	Room	2	.	.	.	0	0	0	0	0
Day 13	R2	Room	2	.	.	.	2041.1149	0	0	0	0
Day 15	R2	Room	2	.	.	.	3317.0513	0	.	0	0.023
Day 0	C2	Calgas	2	.	.	.	.	.	.	.	.
Day 1	C2	Calgas	2	.	.	.	.	.	.	.	.
Day 2	C2	Calgas	2	.	.	.	11511.589	0	12901.985	0	0
Day 3	C2	Calgas	2	.	.	.	10765.377	0	12243.091	0	0
Day 4	C2	Calgas	2	.	.	.	7951.6122	407.17515	10806.811	0	0
Day 5	C2	Calgas	2	.	.	.	9608.6051	0	13937.902	0	0
Day 6	C2	Calgas	2	.	.	.	10406.736	.	9947.6362	0	0
Day 7	C2	Calgas	2	.	.	.	.	.	.	.	.
Day 9	C2	Calgas	2	.		.	.	.	.	.	.
Day 11	C2	Calgas	2	.	.	.	9992.9187	307.49508	11980.571	0	0
Day 13	C2	Calgas	2	.	.	.	11666.388	0	10490.63	0	0
Day 15	C2	Calgas	2	.	.	.	4119.78	355.38519	2263.7371	0	0