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Utilizing the Poultry Carbon Foot-Print Calculation Tool to Estimate and Mitigate the Greenhouse Gas Emissions from Broiler Complexes in Different Regions of Georgia

Abstract

A study was conducted to evaluate the greenhouse gas (GHG) emissions from three broiler complexes located in southern Georgia, central Georgia and northern Georgia. The estimations of the greenhouse gases were done using a Poultry Carbon Footprint Calculation Tool, designed specifically to calculate emissions from broiler grow-out farms, pullet farms or breeder farms. Activity data from a specific year were collected from ten broiler farms in a complex from each region. The activity data were then used to calculate the emissions from mechanical sources (heaters, etc.), non-mechanical sources (manure, etc.), and electricity use. The calculation tool was also used to make recommended changes on the farms, which would reduce the emission.

The results from the study showed that there were no significant differences ($p \leq 0.5$) from non-mechanical sources among the three complexes. However, the study also showed that farms in the southern region of the state had significantly higher ($p \leq 0.5$) total GHG emissions (463.5 kg CO_2e per year) than the farms in the central and northern regions of the state. It was also observed that the projected emissions (after improvements) from mechanical sources from all three complexes were significantly

reduced from the current emissions. For example, the emissions from the farms in the central region of the state were reduced from 314.6 kg CO_2e per year to 187.4 kg CO_2e per year. The results from the study showed that GHG from poultry production farms may differ based on many different factors and location might be one factor.

Introduction

Greenhouse gases (GHG) and their effects on climate change are a component of public environmental awareness. Climate change is often used to describe the GHG effect caused by human activities, which include modern agricultural practices. According to the European Commission-Joint Research Center (2009), carbon footprint is the representation of cumulative carbon dioxide and greenhouse gas emissions associated with a product. A carbon footprint involves not only CO_2 emissions but also includes N_2O and CH_4 emissions which are expressed in CO_2 equivalents (CO_2e). A CO_2e is the concentration of CO_2 that would give the same levels of radiative properties as a given amount of CO_2. This is calculated over a specified time period and must be stated whenever a global warming potential (GWP) is stated. The GWP is a measure of how much a given mass of GHG is estimated to contribute to global warming. For example; GWP over 100 years for N_2O is 298 (IPPE, 2006).This means that the emission of 1 million tons of N_2O is equivalent to 298 million tons of CO_2 over 100 years and the GWP over 100 years for CH_4 is 25 (IPCC, 2006). Within the agricultural sector, carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) are the GHG of primary concern (Johnson et al, 2007). They occur naturally in agriculture while other GHG such as hydrofluorocarbons and sulfur hexafluoride are not typically associated with agricultural sources (Johnson et al, 2007). In 2006, the Intergovernmental Panel on Climate Change (IPCC) (Penman et al., 2006), stated that nitrous oxide is mainly emitted as a by-product of nitrification (aerobic transformation of ammonium to nitrate) and de-nitrification (anaerobic transformation of nitrate to nitrogen gas), which commonly occurs when fertilizers are used. They also stated that methane is emitted when organic carbon compounds break down under anaerobic conditions. These anaerobic conditions can occur in the soil, in stored manure, in an animal's gut during enteric fermentation (mainly in ruminants) or during incomplete combustion of burning organic matter (Penman et al., 2006). A report from the Food and Agriculture Organization (Steinfeld et al., 2006) stated that livestock are responsible for 18% of the global anthropogenic GHG emissions (Steinfeld et al., 2006). The 2013 inventory of the United States GHG emissions separated the major emitters into categories. They concluded that the primary emitters of GHG were energy use with 86.6% and agriculture, which was responsible for 6.9% GHG emission in the United States (EPA, 2013). Of this 6.9%, beef cattle accounted for about 37%, dairy cattle 11.5%, swine 4.4% and poultry 0.6% according to the United States Agriculture and Forestry Greenhouse Gas Inventory, 1990-2011 (EPA, 2013).

The poultry industry is a major part of the agricultural industry in the United States, and while the figures for poultry production appear to be low, understanding how these GHG are generated and mitigation strategies to further reduce the impact is critical for the poultry industry.

Contrary to what the word implies, a carbon footprint involves not only CO_2 emissions but also other greenhouse gas emissions, which are expressed in CO_2 equivalents (CO_2e). A CO_2e is the concentration of GHG that would give the same levels of radiative properties as a given amount of CO_2 (IPCC 2006). Much of the CO_2e that is generated from the poultry industry is primarily from feed production, the utilization of fossil fuels and manure management (Pelletier, 2008; Dunkley et al., 2015) Fossil fuel use may be from purchased electricity; propane or natural gas used in stationary combustion units such as furnaces and incinerators; and diesel used in mobile combustion units such as trucks, tractors, etc. and generators that are used on the farm. Reductions in the carbon footprint of poultry production will require the identification and adoption of on-farm management practices and technological changes in production and waste management that can result in positive net changes for producers and the environment.

The results from a study at the University of Georgia evaluating the carbon foot-print of poultry farms in the US indicated that the utilization of fossil fuels, specifically propane gas, for heating houses generated the most GHG on broiler and pullet farms (Dunkley et al., 2015). In this study approximately 90% of the emissions from the broiler and pullet farms were from propane use while only 5.6% of the total emissions from breeder farms were from propane use. The propane used on these types of farms was mainly for heating during brooding and in the colder times of the year (Dunkley et al., 2015; Hamerschlag and Venkat, 2011). The current study was conducted using a Poultry Carbon Footprint Calculation (PCFC) tool specifically designed and developed for the commercial broiler industry. The objectives of this study were to: 1) evaluate the GHG emissions from broiler farms located in different regions in the state of Georgia, 2) make abatement or mitigation recommendations based on the farms studied, and 3) compare the differences in emissions after the recommended changes have been applied in the calculation tool.

Methods

A study was conducted with three commercial broiler complexes in three regions of Georgia: the southern region (SR), the central region (CR), and the northern region (NR). The study was done to assess the effect of region on GHG emissions and to compare the projected emissions between pre-recommendation and post-recommendation emissions. Ten broiler grow-out farms from each of the three regions were selected to be test farms after a pre-screening to ascertain that the farms were energy efficient. The farms selected varied in house structure and age. The houses were either 50 X 500 or 40 X 500 square feet. Data were collected from a questionnaire that was distributed to and completed by the poultry producers. The two-page questionnaire included detailed information of the farm operations. The farm information included: number of houses on the farm, size of house, construction of house, method of waste disposal, number of birds/flock, and number of flocks/year. The activity data included: electricity usage in kw/H, gallons propane used, and gallons diesel fuel used as obtained from farm records (World Research Institute, 2007). Emissions associated with manure management were evaluated using emission factors from IPCC (Penman et al., 2006). All emissions were calculated using the PCFC tool. The tool was designed to calculate emissions from broiler grow-out, pullet or breeder farms. The tool populates an inventory (Figure 1) of all the emissions (including the type of GHG) from the different sources on the farm. It also has a recommendation section where the recommendations proposed in the tool are designed to reduce energy use by reducing kWh of electricity, liquid petroleum gas, natural gas and diesel fuel use. Recommendations are made based only on the specific farm and as many recommendations as needed can be selected. After the recommendations are selected, the tool then allows the user to see the current emissions and compare them to the projected emissions based on the recommendations.

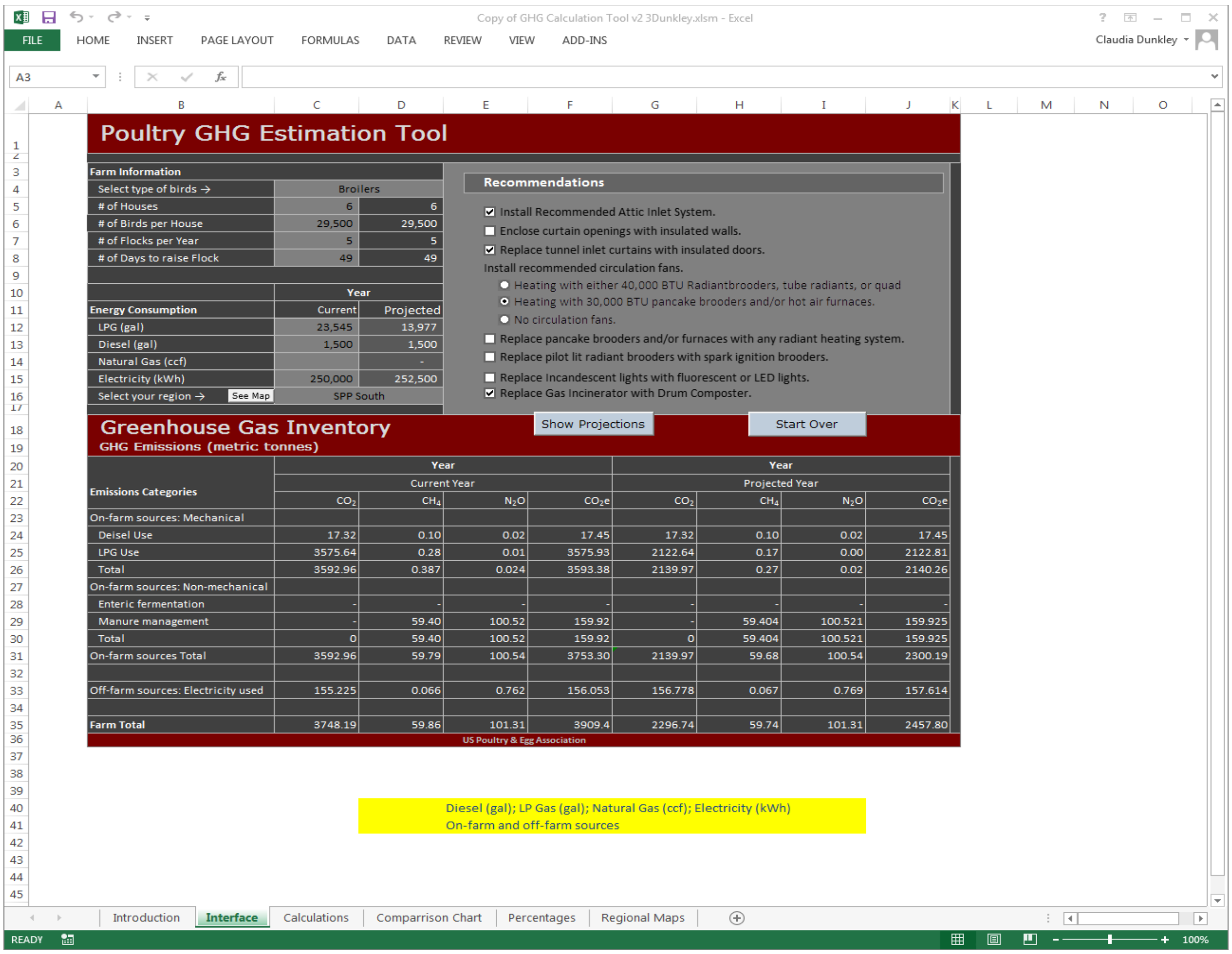

Figure 1. The interface page of the PCFC tool.

Statistical Analysis

All data collected were analyzed with the GLM procedure of SAS (version 9.2, SAS Institute, Inc., Cary, NC) using a one-way analysis of variance (ANOVA) to determine the mean differences between regions (e.g., SR, CR, NR). Once means were determined to be significantly different, they were separated using the Tukey-HSD multiple comparisons procedure. Difference in means were regarded as significant at $P \leq 0.05$.

Results and Discussions

It has already been established from a previous study that GHG emissions vary widely among poultry farms due to the wide range of factors that affect the rate of emissions from poultry houses (Dunkley et al., 2015). Some of these factors include the age and structure of the houses. Whatever the emissions, each poultry grower has the opportunity to reduce these emissions based on the recommendation application in the PCFC tool. The results from this study demonstrated that there were some differences in emissions based on the region of the state where the farms were located, however, the difference can also be as a result of differences in management.

Emissions from the three complexes

Emissions were reported in three areas.

- Mechanical sources include heating systems, incineration, diesel for tractors, generators, etc. Emission data were based on liquid and gas fuel use.
- Non-mechanical sources include primarily emissions from manure management (Hamerschlag and Venkat, 2011). These emissions were estimated based on the type of operation, number and size of birds and how long the birds are raised.
- Electrical sources include ventilation, lighting, and various other equipment that required electricity for operation. Emissions were based on the use of electrical energy on the farm even though the electricity was generated off the farm.

The emissions from the mechanical sources (Table 1) showed that the farms from the SR complex had significantly higher ($p<0.05$) emissions of 435.4 kg CO_2e /house /year, when compared to the emissions from the CR and NR complexes with 314.6 kg CO_2e /house /year and 293.4 kg CO_2e /house /year respectively.

Table 1: Average house emissions from broiler complexes located in three different regions of Georgia. SR = southern region; CR = central region; NR = northern region

Farms	On-Farm Sources[1]			Electricity Use	Total Farm CO_2e
	Mechanical[2] Sources	*Non-mechanical[3] Sources*	*Total*		
SR Complex	435.4±105.1[a]	27.1±1.5	463.5±104.7[a]	28.0±7.2[a]	490.5±106.5[a]
CR Complex	314.6±96.7[b]	25.1±4.9	338.5±98.6[b]	19.3±3.3[b]	357.7±97.7[b]
NR Complex	293.4±95.1[b]	23.9±3.3	318.5±95.7[b]	18.2±9.3[b]	336.7±99.4[b]

[1] Sources of emissions that took place on the farm.
[2] Means from mechanical on-farm sources of emissions from: heating, incineration and other activities using fossil fuel.
[3] Means from non-mechanical on-farm sources of emissions from manure management.
[a-b] Superscripts represent means within the same column which were significantly different. P-value was set at $p < 0.05$.

This could be because the farms involved in the study from the SR Complex all utilized incinerators for their dead bird disposal, while the farms in the study from the NR and CR complexes utilized mainly burial and composting. In 2004, Kastner and Phebus documented that incineration was a fuel intensive operation. As was expected in this study the complexes that did not utilize fossil fuel for their dead bird disposal had a lower fuel usage.

Another fuel intensive operation on poultry farms is the heating of the houses during the brooding period. Heat loss during this period would mean that more fuel will be used to bring the houses to the optimum temperature during the 2-week brooding period for each flock. Two of the 10 study farms in the CR complexes had curtain-sided houses, and this could be the reason the emissions from the CR was higher than the NR, which had only solid-walled houses.

There were no significant differences (p>0.05) in emissions from non-mechanical sources (Table 1) among the three test complexes. This is likely a result of all three complexes utilizing similar manure management practices. The results for electricity use (Table 1) showed that the SR complex had significantly higher emissions from electricity use (28.0 kg CO_2e/house/year) than the CR and NR complexes. There were no significant differences between the CR (19.3 kg CO_2e/house/year) and NR (18.2 kg CO_2e/house/year) complexes. Electricity is used in poultry houses to operate the mechanical processes of the house such as lights, automatic feeding and the fans.

There is a 5-10 degree difference in temperature between the northern regions of the state and the southern regions. This difference in temperature range could account for some of the differences in emissions from electrical sources, from the NR to SR but it must also be noted that other factors such as the type of light bulb (LED, incandescent, fluorescent etc.) could also play a role in the amount of electricity use, hence, the GHG emitted from electricity use.

The total GHG emissions (Table 1) from the three complexes involved in this study show the SR complex (490.5 kg CO_2e/house/year) having significantly higher ($p \leq 0.05$) emissions than the CR (357.7 kg CO_2e/house/year) and NR (336.7 kg CO_2e/house/year) complexes. There were no significant differences ($p \leq 0.05$) between the CR and NR complexes.

Emissions if mitigation/recommendations changes were made

Recommendations for mitigation were made based on the individual farms in each of the study complexes. The results showed that the emissions from mechanical sources in the SR complex (Figure 2) would be significantly reduced ($p \leq 0.05$) to 281.1 kg CO_2e /house/year from the original emissions (435.4 kg CO_2e /house/year) if the recommendations were applied.

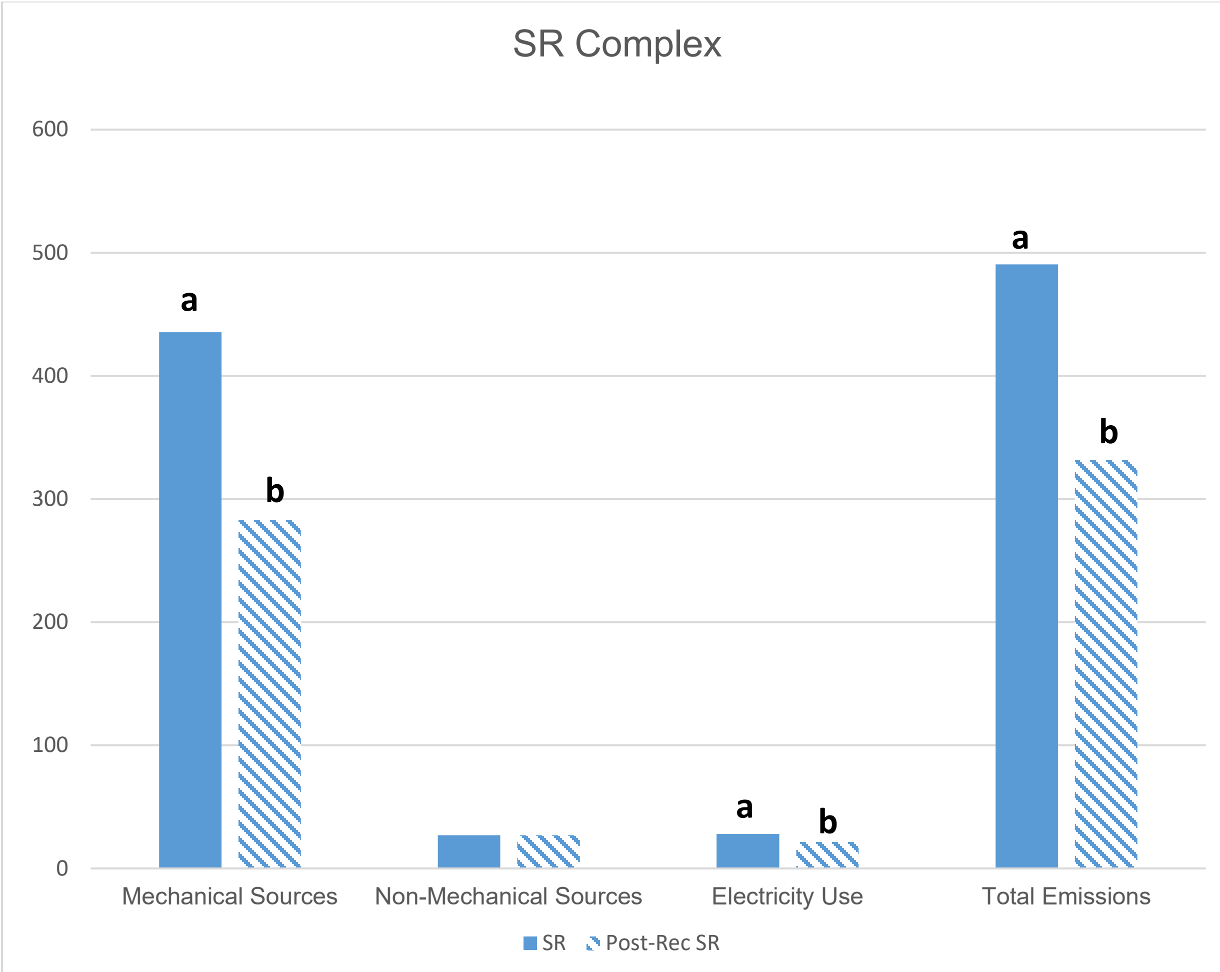

Figure 2. The emissions from the southern region complex before and after if the recommendations were applied. Bars with a different letter in each source of emission show a significant difference ($p \leq 0.05$).

Emissions from electricity use were also reduced significantly ($p \leq 0.05$) from 28.0 kg CO_2e /house/year to 21.6 kg CO_2e /house/year. The total emissions per house (490.5 kg CO_2e /house/year) in the SR complex also showed significant ($p \leq 0.05$) reductions (331.8kg CO_2e /house/year) if the recommendations were applied. The recommendations for the farms in this complex were: convert to drum composter, install attic inlets and replace tunnel curtains with insulated doors. Similar results were observed for the CR complex (Figure 3.) when the recommendations were applied to the calculation tool.

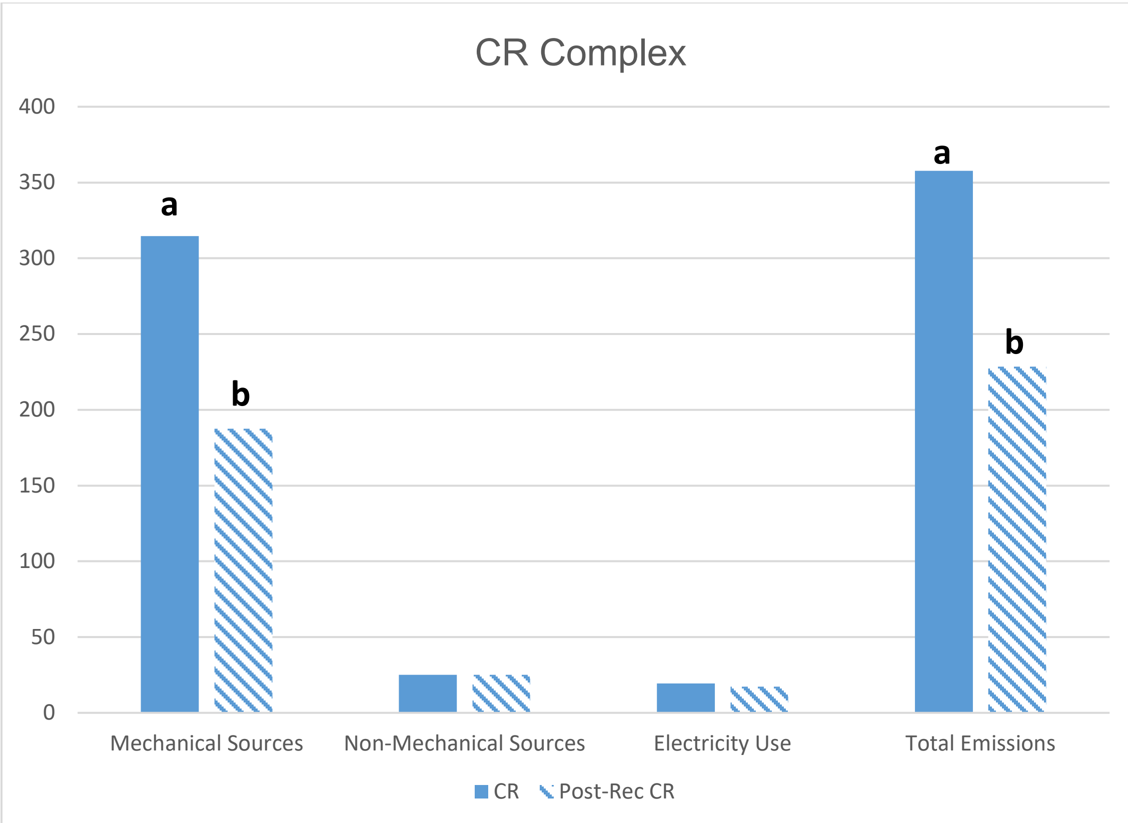

Figure 3. The emissions from the central region complex before and after if the recommendations were applied. Bars with a different letter in each source of emission show a significant difference ($p \leq 0.05$).

There would be a significant reduction ($p \leq 0.05$) in the emissions from mechanical sources in the CR complex if the recommendations were applied with the emissions reducing from 314.6 kg CO_2e/house/year to 187.4 kg CO_2e /house/year. Electricity emissions would be reduced (not significantly) to 17.3 kg CO_2e /house/year from the previous rate of 19.3 kg CO_2e /house/year and the total emissions would be significantly ($p \leq 0.05$) reduced from 357.7 kg CO_2e /house/year to 228.5 kg CO_2e /house/year, post recommendations. The recommendations for the farms involved in the study in this complex were: enclosing the houses with curtain sides with solid walls, installing attic inlets and heating with 30,000 BTU pancake brooders and/ forced air furnaces. As with the other two complexes, NR complex (Figure 4.) also projected reductions in emissions if the recommendations were applied.

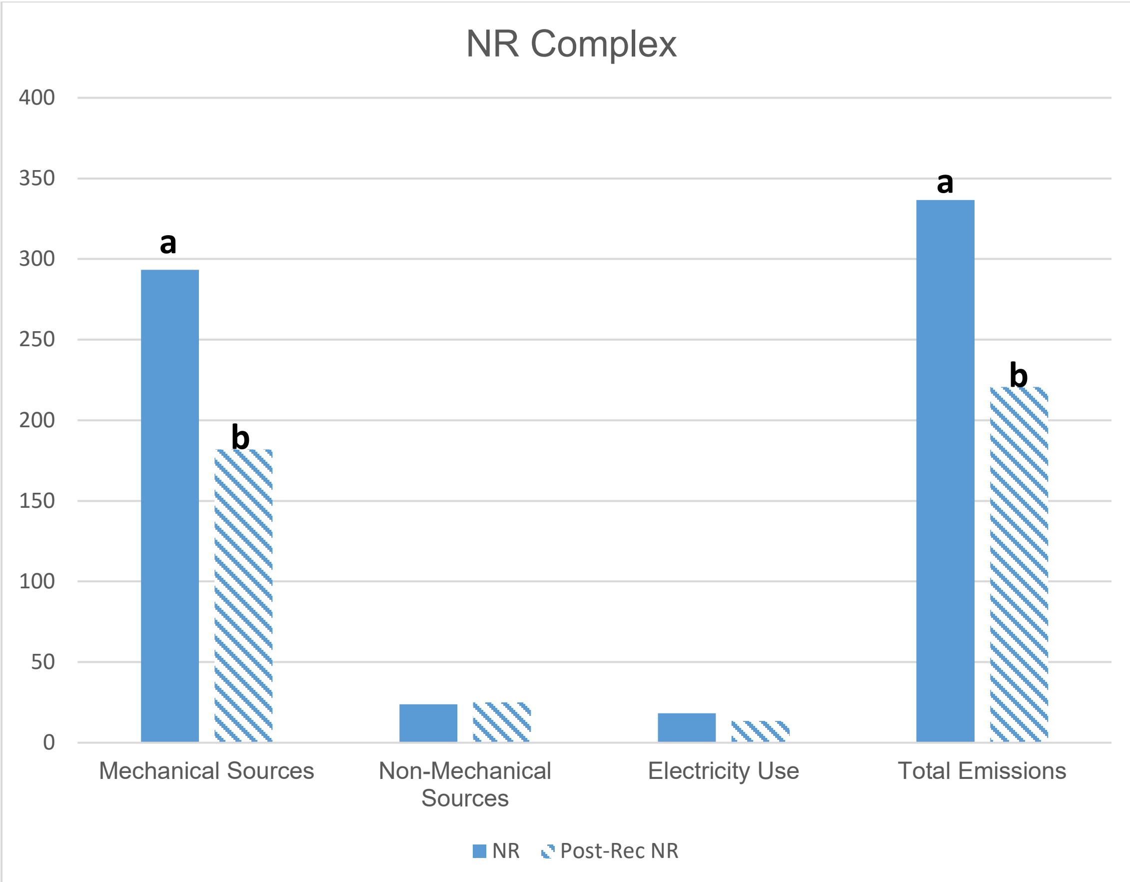

Figure 4. The emissions from the northern region complex before and after if the recommendations were applied. Bars with a different letter in each source of emission show a significant difference ($p \leq 0.05$).

Emissions from mechanical sources would be significantly reduced ($p \leq 0.05$) from 293.4 kg CO_2e /house/year to 181.9 kg CO_2e /house/year if the recommendations were applied according to the tool. Emissions from electricity use would also be lower with only 13.6 kg CO_2e /house/year down from the previous emissions of 18.2 kg CO_2e /house/year, this reduction was not considered significant ($p > 0.05$). The total house emissions from the NR complex was 220.6 kg CO_2e /house/year down significantly ($p \leq 0.05$) from 336.7 kg CO_2e /house/year. The recommendations for the NR complex included: replacing tunnel inlet curtains with insulated doors, replacing incandescent lights with fluorescent light and installing attic inlets. The emissions from non-mechanical sources from all the complexes remained the same because these emissions were based on the number of birds raised, the number of flocks per year and the type of operation.

Conclusions

Energy use is the greatest emitter of GHG in the US. On the poultry farm, energy use is also the greatest emitter of GHG. Geographical regions can have an impact on the amount of GHG that is emitted from a poultry farm. Although there was not a great difference in the climatic conditions between the three broiler complexes examined in this study, there were marked differences in the emissions from the SR complex when compared to the other two complexes. The PCFC tool is a user-friendly tool that is easily accessible to poultry producers. At the end of the calculations, the grower will be able to print an inventory for record keeping and can use this inventory to track the changes of their emissions from year to year. They will also be able to apply the recommended changes and see the projected effect this will have on reducing the farm emissions and effectively on their energy bill.

Applications and takeaways:

- Emissions from mechanical sources such as fuel used for heating the houses and for incinerations tend to be higher than emissions from any other source on the farm.
- Emissions from mechanical sources can be greatly reduced by enclosing curtain sided houses, installing attic inlets and by replacing tunnel inlet curtains with insulated doors.
- By simply converting to drum composting from incineration as a means of dead bird disposal, a grower will noticeably reduce the farms' GHG emissions and reduce fuel costs.
- All recommendations must be addressed to meet the specific farms' need.

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