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Accounting for greenhouse gas emissions at farm level

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Abstract: One of the main causes of climate change is greenhouse gases, which are dominated by an increased amount of CO_2 in the atmosphere. The agricultural sector is one of the most important sources of greenhouse gas emissions. The goal is to prepare the calculation models-system at the farm level. When reducing GHG emissions, it is important to accurately determine gas emissions at the farm level. While applying the GHG emissions accounting model, it is aimed to assess emission sources and apply effective measures to reduce gas emissions.

Keywords: barley yield; bacteria; potassium; phosphorus; soil

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1. Introduction

Gases evaporate from manure, mass exchange takes place between the liquid on the manure surface and the surrounding air flow. This evaporation process corresponds to the general structure of all evaporation processes, and the basis of its structure is convective mass exchange, where the gas flow varies depending on the convective mass transfer coefficient and the gas concentration gradient on the surface of the manure layer and on the surface of the manure (Rong et al., 2009). When choosing methods for the study of GHG emissions, it is necessary to evaluate the technology and technical solutions of keeping animals in the barn. When modernizing animal husbandry technologies, it is very important to reduce the impact on environmental pollution. Gas emissions must be reduced at all stages of manure management: barns, manure pits and during transport and incorporation of manure into the soil (Rzeznik et al., 2015; Zhang et al., 2005; Wu et al., 2012). In order to account for the modelling of greenhouse gas (GHG) emissions at the farm level, it is necessary to define the main farm components from a farm-wide perspective (Schils et al., 2007).

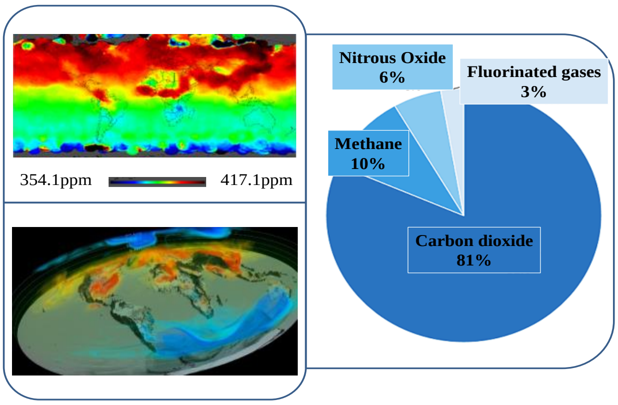

Figure 1. Simulation of CO_2 moving around the planet, from NASA Orbiting Carbon Observatory–2 Satellite's grading spectrometer (NASA/JPL–Caltech) by measuring CO_2 levels with a precision of about 1 part per million. Interval of averaged CO_2 concentration from 354.1ppm–min value (marked by blue color) to 417.1ppm–max value (marked by red colour) (IPCC, 2014; U.S EPA, 2018).

In animal husbandry, the most GHG emission into the environment is CH_4 gas, which accounts for as much as 91% of GHG emissions in animal husbandry: 79.0% evaporates from animal digestion processes and 11.6% from manure management systems. Most methane evaporates from the digestive systems of cows (55.6%), from other cattle - 39.2%, and from sheep - 3.0%. In order to determine GHG emissions in animal husbandry, it is necessary to estimate emissions of the following gases: methane (CH_4); nitrous oxide (N_2O). Understanding the carbon cycle is important for developing strategies to reduce CO_2 (Figure 1).

1. Method

The accounting system for GHG emissions and CO_2 absorptions at the farm level is an IT tool created according to specially prepared GHG calculation methodologies, adapted formulas with selected variables and parameters. The prototype of the created accounting system is intended for use in the accounting of national greenhouse gas emissions and in "green" certification, for providing consulting services. By applying the GHG emissions accounting system, the main aspects of the activities of the mixed, animal husbandry and crop farms that influence GHG were evaluated.

It is mandatory to use the GHG accounting methodology of the Intergovernmental Panel on Climate Change (IPCC - Intergovernmental Panel on Climate Change). According to the IPCC methodology, based on the experience of other countries, a spectrum of GHG emission sources has been determined at the farm level, including criteria defining the sustainability of the farm, and a methodology and system for accounting for GHG emissions at the farm level has been created. The developed model-system for calculating GHG emissions is calculated in three stages. The animal population is divided into subgroups and each of them is described. The emission coefficients of each subgroup in kilograms per animal per year and the number of animals in the subgroup are evaluated. Three (Tier 1, Tier 2, Tier 3) detail and complexity methods were used for calculation. The accounting system for GHG emissions at the farm level is created according to specially prepared GHG calculation methodologies, adapted formulas with selected variables and parameters. It calculated main parameters - enteric fermentation, CH_4, direct and indirect N_2O emissions, recalculated CO_2 eq and total emissions from manure management (Figure 2).

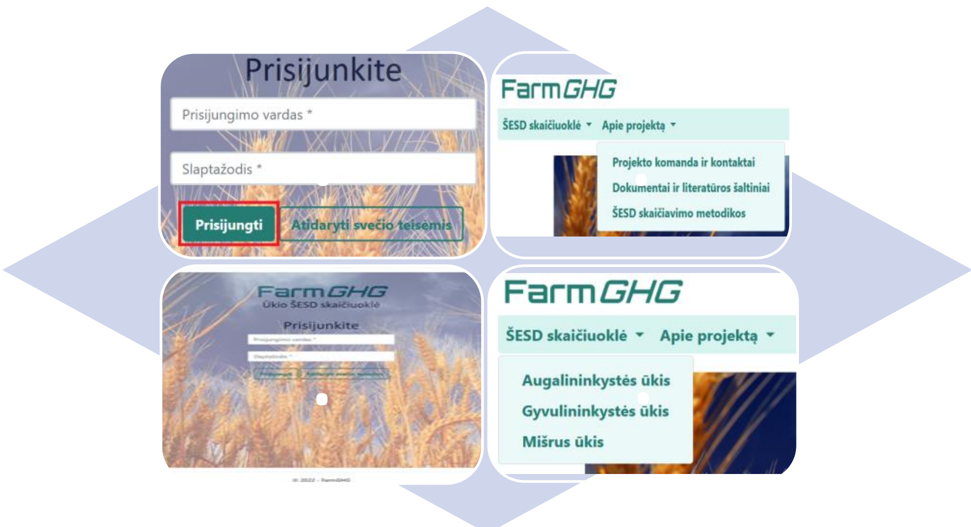

Figure 2. The visualization of accounting system for GHG emissions at the farm level (Link to the new tool created - FarmGHG - http://176.223.141.152/FarmGHG).

The calculation platform was tested by 3 scenarios. SC1 - pasture 25%, solid manure management system 75%, SC2 - pasture 0%, solid manure management system 100%, SC3 - aerobic recycling 100%.

Methane gas emissions are determined from animal digestion processes and manure management technologies, nitrous oxide - direct and indirect emissions from manure. When calculating or experimentally determining the emission coefficients of methane and nitrous oxide gases, it is necessary to evaluate the conditions of keeping animals, the applied modern manure management technologies (manure removal from the barn, manure pits, manure incorporation into the soil), applied bio measures to optimize fermentation and microbiological processes, and temperature changes. A methodically based GHG accounting system, which will record more accurate data collection in specific farms, would enable the state to know problem areas to which support measures aimed at reducing GHG emissions could be directed more appropriately, to carry out monitoring and to analyze the benefits provided by the support.

3. Results and Discussion

After calculation platform assessment of different scenarios when is simulating different manure management such effective measurements for GHG reduction. It was evaluated that SC1 scenario (pasture 25%, solid manure management system 75%) when average number of animals 459 and animal weight 500 kg, was effective and 5% reduce CO_2 eq per year. SC2 scenario (pasture 0%, solid manure management system 100%) was more effective and 15% reduce CO_2 eq per year. The most effective was scenario SC3 (aerobic recycling 100%) and more then 19% reduce CO_2 eq per year (Figure 3).

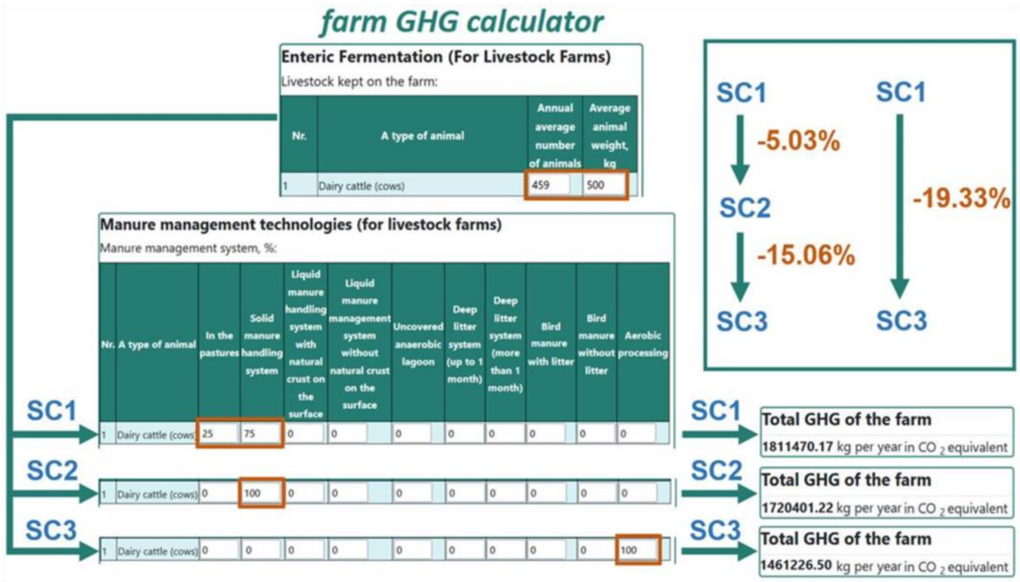

Figure 3. The effect of different manure management scenarios on Total GHG of the farm (Link to the new tool created - FarmGHG - http://176.223.141.152/FarmGHG).

Various researchers are searching and testing different methods and measurements to reduce GHG emissions from agriculture. Some scientific studies have determined the effectiveness of using bio-measures in reducing GHG emissions (Figure 4).

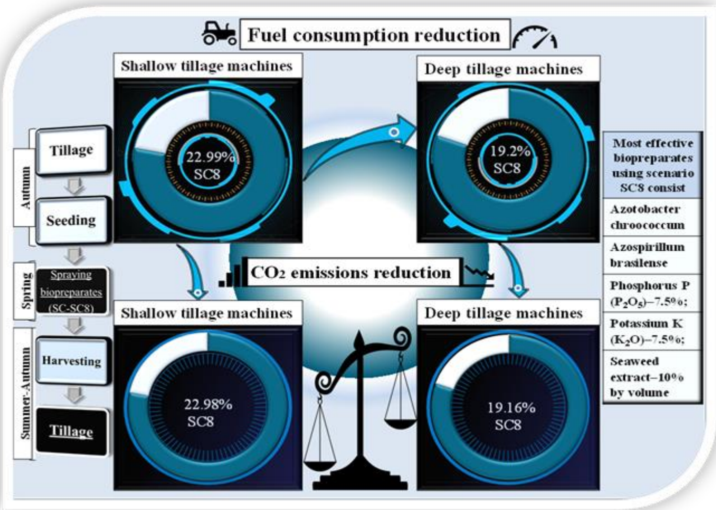

Figure 4. Bio method effect on CO_2 emission reduction in crop production (Naujokienė et.al., 2018).

It was achieved by measuring with gas analyzers a CO_2 reduction from 19 till 23 % of plowing fuel consumption after use of biological preparations in spring, when winter wheat vegetation is restored (Naujokienė et.al., 2018).

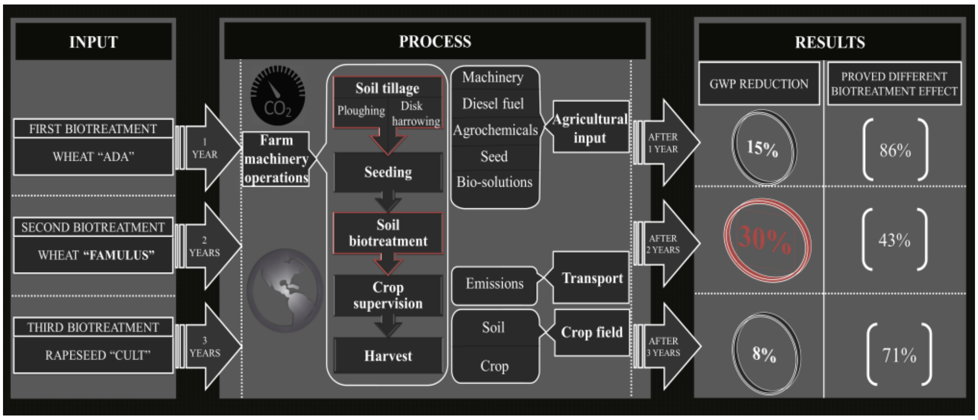

Figure 5. CO_2 eq reduction during the LCA phase (Naujokienė et. al., 2019).

Efforts are also being made to find ways and tools to calculate GHG emissions and one of them is life cycle analysis. The maximum effectiveness of biopreparation for CO_2 eq reduction during the LCA phase via fixed soil tillage was approximately 15% for the mixed biopreparation variant in first year, approximately 8% for the mixed biopreparation variant in second year, and approximately 30% for the mixed biopreparation variant in third year (Naujokienė et. al., 2019). Other researchers have also developed similar platforms for GHG calculation, but their basis was questionnaire assessment, which is not always attractive and methodologically efficient, such as the assessment of production-induced GHG pollution by survey (Tongwane et al. 2016) or the methodology for software assessment of specific GHG emissions of olive farms (Gkisakis et al. 2020).

4. Conclusion

After analyzing all the factors that shape emissions at the farm level and correctly reflect sustainable farm actions that ensure the principles of circularity and sustainable resource use, the FarmGHG calculation tool will help determine the emission sources of technologies and tools applied on the farm according to the IPCC methodology.

A methodically based GHG accounting system, which will record more accurate data collection in specific farms, would enable the state to know problem areas to which support measures aimed at reducing GHG emissions could be directed more appropriately, to carry out monitoring and to analyze the benefits provided by the support.

The FarmGHG assessment system is an effective tool for consultants providing consulting services, preparing farm sustainability plans and monitoring the results of the implementation of measures. Also, more detailed farm-level data will allow the farmer to make individual decisions related to reducing greenhouse gas emissions, optimizing the farm, and increasing productivity.

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