ANALYSIS OF AGRICULTURAL METHANE SOURCES IN UKRAINE AND EXPERIMENTAL ASSESSMENT OF METHODS FOR ITS EMISSION MITIGATION IN LIVESTOCK INDUSTRY

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ABSTRACT

Previously Ukraine was considered as a rather large emitter of greenhouse gases (GHGs) due to its intensive basic industries. In 1990 greenhouse emissions amounted to 900 mln. ton in carbon equivalent. At present, because of substantially declined industrial production, these emissions total 450-500 mln. ton in carbon equivalent. Nevertheless, major sources of greenhouse gases still remain power generating, coal, oil and gas, metallurgy and chemical industries. At that, mitigation of methane emission, in particular of that from coal, is considered as a priority.

As to natural and agricultural methane sources, the animal industry livestock from the point of inventory of the gas and assessment of its contribution to global processes

With a support of United States Environmental Protection Agency we have conducted studies on the assessment and forecasting of methane emissions from cattle subject to the environmental and economic situation in Ukraine, the livestock industry intensification degree, and animal feeding conditions. A few series of trials were devoted to the experimental substantiation of methods of methanogenesis management in cattle.

With cattle inventories totaling 21.6 mln. heads, including 8.1 mln. cows annually yielding on the average 2163 kg of milk per head, in 1994 the methane emission made up 1.3 Tg.

Regarding the methane emission management in Ukraine's livestock branch, its strategy should be based on strengthening productivity, improvement of animal feeding conditions, and use of feed additives subject to the level and characteristics of environmental tension. Utilization of natural mineral silicates, especially zeolite, is worthy of much attention from the point of view of general ecology and particularly radioecology.

By a few series of experimental studies we have established a methane mitigation effect of zeolite as a feed additive for cattle. When kept on pasture, the loss of diet's total energy in cows decreased by 10% owing to lower methane generation. Feeding zeolite with winter diets reduced methane emission by 12.3-14.5% in milking cows.

The methane mitigation effect of zeolite was accompanied by improvement of digestion and nutrition, strengthening of metabolic processes in the organism, increasing of cow milk yields, and higher growth rates in young cattle.

The report also presents results of other studies assisted by modern

equipment, which were conducted in Ukraine as implementation of recommendations of the 1st (Ukraine, Kyiv) and 2nd (Russia, Novosibirsk) International conferences on methane emission mitigation. They involve methods for monitoring and forecasting of methane emissions from various agricultural sources in different ecological conditions, elucidation of mechanisms and stability of factors inhibiting methanogenesis in ruminants.

INTRODUCTION

In 1994-1995 Ukraine became one of the countries where a series of methane emissions investigations organized and funded by United States Environmental Protection Agency (U.S. EPA) and implemented into the practice by a group of scientists with a support of Winrock International Institute for Agricultural Development (Morrilton, Arkansas) to the order of the Atmospheric Pollution Prevention Division, U.S. EPA.

The investigations were focused in particular on the methane emissions level analysis and prediction from cattle depending on technological peculiarities and intensity of dairy and beef cattle production [1].

On June 3-5, 1997, with participation and support of the U.S. EPA at the National Agricultural University of Ukraine, Kyiv, the 1st International Methane Emissions Mitigation Conference was held. The goal of the Conference was to consider the most important technical, ecological and economic aspects of methane emissions mitigation which included: methane role in the atmosphere and global climate changes, political and economic aspects of the arising problem, total evaluation of the programs concerning methane accumulation in the soil and the coal mine and landfill gas emissions mitigation, minimization of the ruminant gas emissions and methane utilization at livestock manure management.

To the main results of the Conference we can also add the following: attracting attention of politicians and governmental institutions, particularly those of Ukraine and other Newly Independent States (NIS) countries, to the increasing role of methane in the set of factors of the global warming effect and necessity of real estimation of its sources, aiming heads of ministries, departments, research and educational institutions at the development of regional strategies of methane emissions control on a basis of relevant international and national research projects.

Among the conference recommendations, along with the methane emissions mitigation from coalmines and landfill, the importance of the problem to minimize the gas emissions from ruminants was also stressed. Methanogenesis as an inevitable consequence of the rumen fermentation processes in ruminants (23%) and manure storing (7%), which together make about 30% of the whole anthropogenic methane, must be considered from the view of economically justified gas emissions control in the context of all regional peculiarities evaluation. And this recommendation underlies the foundation of experimental investigations during the project accomplishment.

With kind support of the U.S. EPA and Winrock International Institute for Agricultural Development the Ukrainian group of scientists at the Washington State University [2,3] introduced and adapted to the Ukrainian conditions the methods of direct measurements of ruminant methane emissions using SF_6-gas tracer, bought the necessary equipment and devices.

All these allowed to start the feasibility study and experimental substantiation of cattle methanogenesis control methods without use of sophisticated and expensive static respiration equipment, application of which is unfortunately rarely available in present-day Ukrainian economic circumstances.

The results of fulfillment of the recommendations of the 1st International Methane Mitigation Conference (Kyiv, 1997) were reported at the second similar conference (Russia, Novosibirsk, 2000). By then the Memorandum of Intent between the Governments of the United States of America and Ukraine on Cooperation on Climate Change Initiatives has been issued, and the United States Agency for International Development has launched its Climate Change Initiative.

Before the 1st and 2nd International Conferences (Kyiv, Ukraine, 1997 and Novosibirsk, Russia, 2000, accordingly) and actions of the Climate Change Initiative there was little understanding and awareness among Ukraine's government officials, industrial enterprise managers and members of non-governmental organizations (NGOs) about climate change issues in general and their impact on Ukraine particularly. Climate change was considered the professional domain of scientific climatologic long-term observations carried out by researchers, including in agriculture.

Just materials of such observations as well as both experimental and analytical studies, which cover almost 100 years, have proven that Ukraine is one of the planet's regions with detectable climate change. The duration of winter periods have substantially decreased and the winter itself becomes warmer. However, the main, extremely adverse trend is an appreciable rise in occurrence of severe droughts. So, 43 dry years were registered in Ukraine in the 20th century, i.e. almost each second year was unfavorable. Seven out of the fifteen last years of the past century were dry. Other natural adversities also became more frequent at this same period: hot winds, heavy showers, icings and floods that are attributed to the climate change.

The First National Communication, by which Ukraine is complying with the obligation to communicate information to the Secretariat of the Intergovernmental Negotiating Committee for a UN FCCC, in accordance with Article 4.2 and Article 12 of the Convention on Climate Change, presents important facts that are directly related to transitional processes in national economy. It is shown that methane contribution to the total budget of GHG emission increased from 23% in 1990 to 35% in 1998. At the same time, contribution of agricultural sources to total methane emissions in the country has not been affected significantly, and dropped from 23.8% to 22.6% respectively. However, such changes illuminate adverse structural changes in national production and a shift towards mostly outdated heavy industries. The showed in the document data reveal that due to inconsistency in restucturization, particularly in metallurgy, and an absence of state energy strategy Ukraine has significant problems with energy efficiency. For example, the document shows that despite total energy consumption in Ukraine declined by 35.9% from 1990 to 1995, energy efficiency dropped as a whole by 33% due to increased energy intensity in most sectors relative to GDP. [4]

Due to the above-mentioned reasons, there expand within the network of the Ukrainian Academy of Agricultural Sciences systematic and purposeful studies of the Ukrainian agriculture's adaptation to the changing climate along

with the development of a set of measures aimed at minimization of the man-caused contribution to the greenhouse effect formation.

As to the forecasted climate change in Ukraine, estimations of some of its parameters under different models evidence that rising warmth will result in scarcer water resources as well as in essential changes in the structure, productivity and management of agriculture [5].

The climate warming in Ukraine has already given rise to the following quite specific effects: (1) smoothing of the climatic field of average monthly near-ground temperatures, (2) decontinentization of the climate, (3) smoothing of the climatic field of annual precipitation totals, (4) nonmonotonic transformation of the climatic field of average monthly precipitation intensities. It is believed that the most disastrous result of the global temperature increase for Ukraine may be a shift of the subtropical cyclones belt towards moderate longitudes of the Northern periphery [6].

RESULTS OF MONITORING OF METHANE EMISSION FROM UKRAINE'S AGRICULTURE

Until recently, due to its well-developed industry, Ukraine was a great emitter of the GHGs. In 1990, which is suggested as a basic year, GHGs emissions totaled 900 mln metric ton in carbon equivalent. Because of the long-drawn crisis in Ukraine's economy and substantial industrial recession, the total GHGs emission presently makes up to 450-500 mln metric ton [7].

Experts point out the following major sources of GHGs in Ukraine: energy and heating, coal production, natural gas and oil systems, ore mining and metallurgical industry, chemical industry, mechanical engineering, building material production, agriculture and forestry, transport. In Ukrainian agriculture there are four the most important sources of methane emissions: rumen fermentation, livestock wastes, rice production and regular agrochemical measures.

Rice production is one of the most significant agricultural sources of methane emission worldwide. Ukraine is not a great rice producing state. Twenty five thousand hectares were in involved In rice production in 1998. However, region-wise this is an important source of methane emissions and as estimated is accounted for approximately 12 ths t of methane per year.

Livestock wastes, particularly manure, is also an important source of methane emission and other gases, but its monitoring is very complicated due to a great diversity of the source itself and ways of its utilization. In confined facilities animal wastes represent a serious environmental danger. According to recent estimations there are about 4.58 mln t of dry matter of livestock manure per year which is available in Ukraine; using existing technologies of anaerobic fermentation this is equal to 68.7 PJ/yr. [8]

Determining priority for regional investment projects for GHGs emission mitigation in these fields the very methane reduction and particularly coalmine are supposed the most important. Natural and agricultural sources of methane emissions in Ukraine have not been estimated precisely yet, excluding livestock production systems. But earlier obtained materials need appropriate re-estimation in accordance with the structural changes that took place in the national agricultural sector.

It should be emphasized that such reformation recently resulted in a considerable increase in cattle number and respectively in dairy and beef product total output in private farms and households. In some Ukrainian regions the enterprises possess about 65% of total cattle herd here now.

The mentioned above changes which are inevitable and vital under current economic circumstances will influence total livestock number and cattle particularly and production conditions that correspondingly affect their methane emissions. This testifies again that whilst discussing any national and regional features of methane emissions from ruminants and its contribution to relevant global processes we should take into consideration overall both ecological and economic situation which determines herd size, level of intensification, stability of cattle production development, livestock genetic potential and peculiarities of their feeding in conditions of man-caused environmental pollution.

Total methane emissions in 1994 from Ukrainian 21.6-million cattle herd, including 8.08 mln cows with average milk yield 2163 kg/hd/yr, was calculated about 1.3 Tg/yr. The need of cattle production intensification, predicted and economically extremely necessary double and even triple increase of milk efficiency of cows could reduce the methane emissions to 0.94 Tg/yr (30% mitigation; total cattle number-17.189 mln, including 6.778 mln. cows) and 0.88 Tg/yr (36% mitigation; total cattle number – 15.002 mln., including 6.731 mln. cows) respectively [1]. But in reality, the total cattle number amounted to 9.07 mln heads as of January 1, 2001, i.e. reduced in two times, including 5.0 mln cows that means a 1.6-fold drop while milk yields dropped as well.

With that cattle population the overall national methane emission from dairy beef cattle amounts to nearly 0.825 mln t/yr, i.e it was 500 ths ton (37.7%) smaller in 2000 than in 1994. However, this reduction is determined by a significant decline in the total cattle number.

METHODS AND RESULTS OF EXPERIMENTAL STUDIES

Our experimental studies are aimed at elucidation of environmental, biological and biochemical aspects and mechanisms of methanogenesis regulation in ruminants. The ultimate aim of this research is optimization of diets and usage of methane-mitigating feed additives. This report presents the results of an experimental study of cow methanogenesis peculiarities in conditions of feeding both “clean” forages and those contaminated by the Chornobyl radionuclides as well as with application of radiosorbing zeolites as feed additives.

When conducting the experiments by the period’s method cows were fed a zeolite additive during the experimental period. The use of the groups and periods method stipulated adding zeolite to diets of animals of the experimental group. Cows of control groups received no zeolite.

Methane emissions from the experimental animals were studied exploiting the SF_6 (sulfur hexafluoride) – gas tracer methods [2,3], which provide the following two directions of their use: (a) measurements in pasture conditions using special rumen permeation tubes with sulfur hexafluoride and (b) measurements within closed premises when sulfur hexafluoride used to be released from a weighed gas-container.

Methane emissions in cows fed zeolite with "clean" diets. In the first experiment it was found out that in conditions of feeding dry calvers (which are typical for the Forest-Steppe zone of Ukraine) not exposed to radio-contamination the average methane emission was about 10 L/hr that should be taken into consideration while determining total methane emissions. The proportion of animals of this physiological state in the herd and their liveweight should be taken into consideration.

The goals of the second experiment of this series included: (1) evaluating the impact of zeolite fed with "clean" diets on cow methane production intensity; (2) testing at the same time the methods of methane emissions measurements using the SF_6-gas tracer by group method in a closed (isolated) building with following the animal keeping technology as thoroughly as possible.

When the radiation factor is absent, feeding 250 g/hd/d of zeolite promotes lower methane emissions from dry calvers. This can be accounted for by either its inhibiting influence on methanogenesis directly, or its effect on rumen fermentation processes (Tab. 1).

The technique of group methane emission measurement using SF_6-gas tracer allows conducting investigations in ruminant methanogenesis with more numerous population. It provides an opportunity to study both age-related features of methane production and effect of different factors of feeding and management on the process with strict observation of the adopted production practice.

Peculiarities of methanogenesis in cows fed zeolite in conditions of grazing on radionuclide-contaminated areas. The objective of one of the second series' experiments was to make an evaluation of zeolite feeding effect on methane emissions from cows grazing on radio-cesium contaminated pastures.

In these conditions the most probable and rather tangible factors of influence on cattle methanogenesis can be (1) long-term radio-cesium supply with forage and (2) systematic feeding of radiosorbing mineral silicates. Therefore, the rumen content and digesta of further digestive tract compartments have higher concentrations of radionuclides resulting in a prolonged common endoecologic effect and influence of each of the mentioned factors on rumen metabolism and methane production.

As seen in Table 2, in conditions of summer management of lactating cows on pastures typical for the Woodland part of Ukraine which were contaminated with radionuclides methane emission was 295 to 320 L/hd/d that is much higher than in dry calvers fed on winter diets (190 to 210 L/hd/d).

When using zeolite as a feed additive the gross diet energy losses due to methane production decreased approximately by 10%, although the antimethanogenic effect of zeolite was insignificant and more appreciable when methane emission reduction was considered on the dietary dry matter unit and milk kilogram basis.

CONCLUSION

Much progress has been done in Ukraine's climate change policy to date. Nevertheless, in opinion of the performers of the Climate Change Initiative, it is necessary to do the following: (1) strengthen institutions and develop

policies needed for the Government of Ukraine to meet its international commitments on global climate change through the creation of market mechanisms to reduce GHG emissions; (2) increase environmental management capacity to reduce GHG emissions both in the public and private sectors and to stimulate investments in and financing for environmental technologies and programs; and (3) increase the involvement of non-government actors (e.g. industry, environmental groups and the public) in the development and implementation of Ukraine's climate change policies and programs [9].

As to agricultural sources of methane emission, a major objective is its mitigation in the livestock branch, particularly in beef and dairy cattle breeding. The strategy should base on strengthening the cattle genetic potential, improvement of the animal nutrition value and use of feed additives, in particular natural mineral silicates (zeolites).

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Table 1. Characteristics of methane emissions from experimental cows

Item	Period		
	Preparative	Experimental	
		absolute value	% to preparative
CH_4 emitted:			
L/head/day, M ± m	210.0 ±14,3	190.6 ±12.6	90.9
L/kg of dry matter, M	23.41	19.97	85.3
L/kg of crude fiber, M	83.00	72.55	87.4
CH_4 energy:			
MJ, M ± m	8.30±0.25	7.55 ±0.32	91.0
MJ/kg of organic matter	1.00	0.88	87.5
Gross energy losses due to methane production, %	5.20	4.73	

Table 2. Methane production by experimental cows

	Day 15			Day 30		
	Control	Experimental	Control to experimental	Control	Experimental	Control to experimental
CH_4 emitted						
Liters/head/day	321.2± 12.2	294.8± 11.7	91.8	319,7± 15.6	307.6± 13.5	96.2
Liters/kg of dry matter	21.84	19.07	87.3	21.96	20.13	91.6
Liters/kg of crude fiber	68.51	60.65	88.5	68.96	64.09	92.9
Liters/kg of milk	31.51	26.80	85.1	32.62	29.29	89.8
CH_4 energy						
MJ	12.71	11.66	91.7	12.64	12.16	96.2
MJ / kg of organic matter	0.99	0.88	88.8	1.00	0.93	93.2
Net energy loss due to methane production, %	5.18	4.71		5.24	5.05	