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ESTIMATION OF THE LEVEL OF GREENHOUSE GAS EMISSIONS IN ANIMAL PRODUCTION

SZACOWANIE POZIOMU EMISJI GAZÓW CIEPLARNIANYCH W PRODUKCJI ZWIERZĘCEJ

Summary*: The aim of the present paper is to show the level of greenhouse gases' emission coming from animal production in Poland. The animal production in 2015 was a source of 39.8 % of GHG emissions of which 30.7 % came from intestinal fermentation and 9.1% derived from animal manure. The animal production has also its share in the emissions resulting from the energy consumption in agriculture; therefore, its participation in the total GHG emission is equal to ca. 50%. Factors affecting the level of greenhouse gases' emissions include: the species, animal breed, performance stage, housing and feeding system and also, the way of natural manure management.*

The foreign literature review shows the chosen methods of GHG emission measurements. The direct methods such as respiration chambers are expensive and labour-consuming; therefore, the indirect methods have been also presented, e.g. the estimation of methane emissions, produced by the dairy cattle, based upon the fatty acid profile in milk.

Keywords*: GHG emission, animal production, measurement, calculations, structure*

Streszczenie*: Artykuł ma na celu przedstawienie wielkości emisji gazów cieplarnianych z produkcji zwierzęcej w Polsce. Produkcja zwierzęca w 2015 r. była źródłem 39,8 % emisji gazów cieplarnianych z polskiego rolnictwa, przy czym 30,7% to fermentacja jelitowa, 9,1% pochodziło z nawozów naturalnych. Produkcja zwierzęca, w ramach zużycia energii w rolnictwie ma także swój udział w emisjach, dlatego łącznie jej udział w całkowitej emisji GHG wynosi około 50%. Do czynników mających wpływ na wielkość emisji gazów cieplarnianych zaliczamy: gatunek, rasę zwierząt, fazę użytkowania, system utrzymania i żywienia a także sposób zagospodarowania nawozów naturalnych.*

W wyniku przeglądu literatury zagranicznej przedstawiono wybrane metody pomiaru emisji GHG. Metody bezpośrednie, takie jak komory respiracyjne, są drogie i pracochłonne, dlatego przedstawiono także metody pośrednie, np. szacowanie emisji metanu przez krowy mleczne na podstawie profilu kwasów tłuszczowych.

Słowa kluczowe*: emisja GHG, produkcja zwierzęca, pomiar, obliczenia, struktura*

Introduction, aim of the work, materials and the methods of analyses

According to the data of the National Centre for Emissions Management (KOBiZE) [Olecka Et Al.], about 29 850 thousand tons of greenhouse gases in CO_2 equivalent (CO_2e) in 2015 derived from Polish agriculture. The mentioned value did not include the emission from the energy carriers in agriculture; according to the methodology employed in the inventory of greenhouse gases, it was included in the part "energy".

Value of carbon dioxide equivalent (CO_2) is calculated by multiplying the mass of the particular gas emission and the corresponding global warming index (GWP) which is the indicator, comparing the quantity of the heat absorbed by the mass of the given GHG in relation to the amount of the heat absorbed by the same quantity of carbon dioxide.

GWP is calculated basing on the results of the effects of impact of one kilogram of a particular gas on the climate warming during the defined time interval, being usually 20, 100 or 500 years in comparison to the impact of one kilogram of CO_2 for which GWP was adopted as 1. Value of GWP for methane as adopted in the present work is equal to 25 and for nitrous oxide it is 298.

According to the data of KOBiZE, the participation of agriculture in the national greenhouse gas emissions (excluding LULUCF) was equal to 7.68%. In the case of the particular gases, the mentioned participation was strongly differentiated and it was shaped as follows: for carbon dioxide – 0.16%; for methane – 29.81% and for nitrous oxide – 78.03 % of the national emission.

Despite its relatively low participation in the total mass of GHG emission in Poland, the agriculture has a big share in methane and nitrous oxide emission. A similar situation is in other countries what has been confirmed by the data from the foreign literature; it is followed from the mentioned materials that the majority of the GHG other than CO_2 emitted all over the world, comes from the agriculture. Its participation in the total emission of methane (CH_4), nitrous oxide (N_2O) and fluorinated gases, calculated into carbon dioxide (CO_2) is equal to 53% [Beach Et Al. 2015]. In Poland, the discussed participation amounts to 40%, so, it is by 13 percentage points lower than the world mean.

When considering the GHG emission caused by the use of energy carriers in Polish agriculture, the participation of the mentioned sector of the national economy in CO_2 emission in 2015 amounted to 4.29%, that is, it was by 3.39 pp higher than the value given by KOBiZE; its participation in the structure of GHG emission in Polish agriculture was equal to 27%. In this case, the participation of nitrous oxide and methane (36% each in the structure of GHG, emitted as a result of the agricultural activity in Poland) was higher than that of carbon dioxide.

The participation of fluorinated gases was equal to ca. 1%. In total, the greenhouse gases other than CO_2 constituted 73% of the total GHG emission in Polish agriculture and 39.6% of the emission of the mentioned gases in the whole national economy of Poland [PAWLAK 2017]. According to the EPA data [2017], the participation of the world agriculture in the emission of greenhouse gases other than CO_2 in 2015 was equal to 49.2% and was by 9.6 pp higher than in Poland. The discussed share in the particular regions of the world is strongly differentiated. In 2015, it varied from 16.1% in the Middle East countries up to 78.2% in the countries of the South and Middle America.

In 2015, the highest quantity (39.8%) of greenhouse gases, emitted in Polish agriculture, came from the animal production, including 30.7% resulting from enteric fermentation and 9.1% coming from livestock natural manure management (Fig.1). Due to the fact that animal production has also its share in the emission, caused by the energy consumption in agriculture, its total participation in the total GHG emission from the Polish agriculture should be estimated at ca. 50%. Animal production is, therefore, a serious source of the emission of greenhouse gases. It determines the meaning of the activities aimed at the reduction of the level of the mentioned emissions in the discussed sector of the agricultural production.

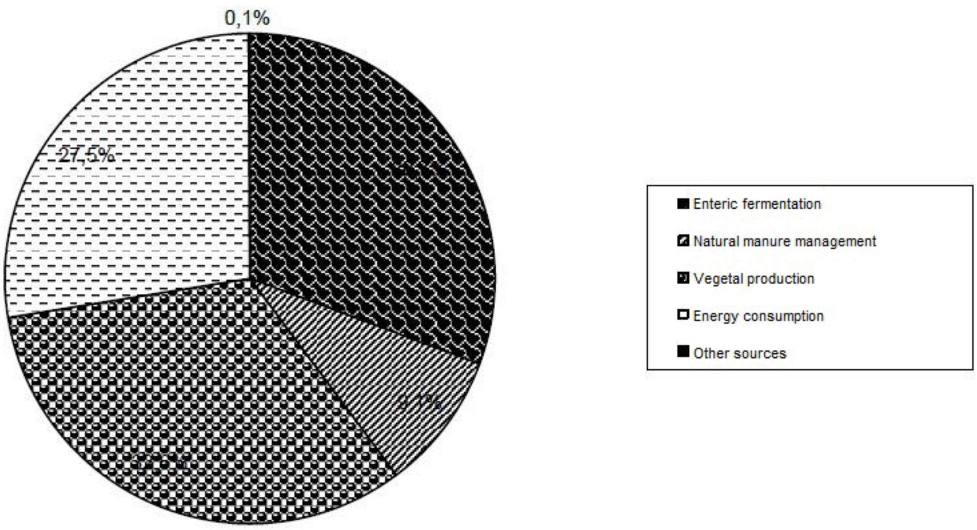
The aim of the present paper is to analyze the role of animal production in the emission of greenhouse gases, with the consideration of their sources and of various types of the conditions, affecting the level of the discussed emissions as well as the method for their measurement and assessment.

The analysis is based upon the review of the national and foreign literature, describing the present situation in respect of GHG emissions in the animal production, the employed methods for their measurement and also, the possibilities of their estimation on the grounds of the parameters of the respective animal products.

Demand on food and the environmental challenges

Dynamically increasing population, especially in the developing countries, causes the increase of demand on food.

Fig. 1. Emission of greenhouse gases in Polish agriculture in 2015 according to the sources [PAWLAK 2017]



In the conditions of the limited and, in some parts of the world, a decreasing area of agricultural land, it is necessary to intensify the agricultural production via increase of the plant yield and the productivity of farm animals.

It is connected with the necessity of increasing the outlays on production means, inter alia, on mineral fertilizers, plant protection agents and energy carriers. In turn, it causes the unfavourable consequences for natural environment, manifested by the increase of the emissions of harmful compounds, including greenhouse gases which deteriorate the quality of soil, water and air. Moreover, in certain parts of the world, a tendency to increase the agricultural areas at the cost of forests is being observed e.g. in the cases of tropical forests in Brazil and Indonesia.

The additional threat to the environment protection consists in the fact that the plants acting as carbon dioxide absorber are decreasing and the potential changes in climate may cause the desertification of new areas of our globe. Meanwhile, the populations in the developed countries demand the increase of the quality of the food products. It is connected with the necessity of supplying the consumers with the information about the place and manufacturing process of the products (traceability of food product).

Meeting the mentioned above requirements is connected with the increase of the unitary manufacturing costs. On the other hand, the main problem in the poor countries is to ensure the sufficient food quantities at the prices affordable for a given population, and to limit hunger zones.

In connection with the above situation, a serious dilemma arises: the increase in food production requires the additional outlays on manufacturing means; their production in non-agricultural zone and their application in the agricultural production are connected with the GHG emission.

The increase in food production should therefore take place together with the simultaneous reduction of the greenhouse gases' emission. It is not the easy task as the current challenges connected with the reduction of GHG emission at the global scale require that the rate of the reduction in the intensity of the GHG emissions must exceed the increase of the productivity, indispensable for meeting the global demand on food [Rawnsley Et Al. 2018].

The discussed challenges concern, *inter alia*, animal production, the participation of which in food production as well as in GHG emission is meaningful.

In the future, the agricultural producers will have probably to consider the introduction of the changes in organization of the agricultural production and the application of different combinations of plant species cultivation or farm animal husbandry and the related changes in their management.

In connection with the above, Antle Et Al [2018] suggest the popularization of the methods of evaluating the impact of such adaptations, being called "inter-system adjustments" and "propensity score matching". On the grounds of the application of the mentioned methods in the selected example, the authors found significant differences between the obtained results which, however, do not seem to be connected with the characteristics of the examined systems. The method employed in the estimation of the productivity of the new system introduces the element of uncertainty to the adaptation analysis. The further studies aimed at evaluation of the alternative methods of the inter-systemic adaptation analysis and the related uncertainties are necessary.

The ruminants such as cows, sheep and goats produce the greatest quantities of methane. In the animal production, methane is produced in the gastrointestinal tract of ruminants (as a result of intestinal fermentation) and in the conditions of anaerobic decomposition of animal natural manure. In cow rumens, there are found ca. 150 billion microorganisms. After completion of the cellulose fermentation, the ruminants swallow the digested food and then it is passed to the successive chambers of the stomach. The whole process is called rumen-reticulum cycle which is composed of a complicated combination of the spasms of the appropriate parts of the forestomachs. In the normal run of the fermentation processes in cow, 25-30 litres of gases are produced during 1 hour. The greatest quantity of the mentioned gases are expelled by belching and only a small part is absorbed by the rumen mucosa or passes to further segments of alimentary tract.

Brittante Et Al. [2018] employed the following indicators, characterizing the methane production as a result of methane fermentation:

- Yield of methane emission, measured in grams and calculated into unit of dry matter [$g \cdot kg^{-1}$];
- Intensity of methane emission, measured in grams per one kg of standardized milk [$g \cdot kg^{-1}$];
- Daily methane production from one cow [$g \cdot day^{-1} \cdot head^{-1}$].

The studies of the cited above authors showed that the values of the majority of the mentioned indicators of methane emission as a result of intestinal fermentation – excluding the yield of methane emission – was increased in the successive lactation periods, from the first one beginning.

The system of animal housing and the frequency of manure removal had a big influence on the emission of greenhouse gases.

The studies conducted in a free-stall dairy cattle barn in Italy revealed that the application of rubber mats on the concrete floor caused the increase of the emission of ammonia, carbon dioxide, nitrous oxide and methane, irrespectively of the way of manure removal. On the other hand, the application of robot for removal of the manure and by this, the increase of the frequency of

Tab.1. The percentage structure of gases in cow rumen according to individual traits and feeding method [own development on the grounds of Moate Et Al. 1997]

Specification	Carbon dioxide [%]		Methane [%]		Nitrogen [%]	
	from – to	Mean	from – to	Mean	from – to	Mean
Before grazing	53.5–74.5	65.5	24.8–40.5	30.9	1.2–6.0	3.8
After grazing	72.3–80.3	75,9	19.0–23.1	22.2	1.0–4.6	1.7

cleaning the floor in the premises, caused a significant reduction of the GHG emission [Chiumenti Et Al. 2018]. The microclimate in the cow barn has the indirect influence on the GHG emissions.

The composition of gases in the cow rumen is dependent on the method of feeding and individual traits of the animal what is supported, *inter alia*, by the results of the studies carried out in Australia [Moate Et Al. 1997]. During the mentioned studies, the composition of gases before and after pasture grazing was compared. The results referring to the animals which were not subjected to the bloat-preventing agents are given in Tab. 1.

Milk production is connected with a high methane emission, resulting from the methane fermentation in alimentary tract of ruminants, managed in agricultural farms. It is necessary to undertake the measures aimed at the reduction of the mentioned emissions. To carry out properly the discussed activities, it is necessary to have the results of the appropriate measurements of GHG emissions, caused by farm animals.

Measurements and estimation of ghg emissions coming from farm animals

Inventory of gas contaminations is carried out basing upon the international methodologies IPCC (eng. Intergovernmental Panel on Climate Change) and EMEP (eng. European Monitoring and Evaluation Programme). In the calculations, standard indicators of GHG and ammonia are mainly utilized. From the analysis of available national and foreign literature it is followed that there are significant discrepancies between the values of the emission parameters. It is affected by many factors such as period of measurements, different micro- and macroclimatic conditions as well as the application of different measuring devices. The studies were conducted mainly in the premises with litter-free housing system; only some of them concerned litter housing system what may result from the relatively small popularity of this type of management in the West Europe. In the studies of gas emissions, conducted in the Wielkopolskie Voivodeship, in pig fattening house on a deep litter, the daily emission of the examined gases was calculated as a ratio of value of their concentration in the studied building and the daily air exchange in the building. The daily indicator of the emission of GHG and ammonia was considered as a quotient of the daily emission of gases and animal body weight; BW of the animals during the measurements was calculated from the results of weighing of the random chosen 5 porkers from each pen. The mean body weight of the porker in the pen was the arithmetical mean of the weighed pigs [Mielcarek Et Al. 2014].

The studies of the methane emission as a result of enteric fermentation in the animals are conducted in the respiration chambers. Placement of the animals in such chambers causes stress what affects the feed intake and, in consequence, CH_4 emission. The research stands require improvements, ensuring the limitation of stress and by this, improvement of the values of the obtained results of the studies [Llonch ET Al. 2018]. The results of the direct measurements of the GHG emissions in the animal production should be, therefore, treated with a certain caution.

Besides it, the measurements of greenhouse gases' emission produced by the animals are difficult and expensive [Brittante Et Al. 2018; Christie Et Al. 2018]. In the light of such situation, Brittante Et Al. [2018] suggest the application of indirect method for the assessment of the methane emission by the dairy cows on the grounds of fatty acid profile in milk. It consists in the utilization of the relationship existing between the activity of microorganisms in the rumen and the particles available for milk synthesis in the mammary gland. When utilizing a gas chromatography of the high number of milk samples coming from 1 158 Swiss Brown cows, managed in 85 farms, the mentioned authors analyzed individual profiles of fatty acids. They verified two equations, applied in the assessment of the methane emission as a result of methane fermentation. They found that the results of the following calculations: the mean estimated yield of methane emission, measured in grams and calculated per one unit of dry matter ($21.34 \pm 1.60\ g \cdot kg^{-1}$), intensity of the methane emission, calculated in grams per one kg of standardized milk ($14.17 \pm 1.78\ g \cdot kg^{-1}$) and daily methane production from one cow ($357 \pm 109\ g \cdot day^{-1} \cdot head^{-1}$) were similar to the earlier published results of the measurements.

When utilizing the data referring to the cheese products coming from milk of the individual cows, the estimated intensity of the methane emission was calculated in terms of one kg of fresh cheese ($99.7 \pm 16.4\ g \cdot kg^{-1}$) and per one unit of mass of solid parts in cheese ($207.5 \pm 30.9\ g \cdot kg^{-1}$).

In the traditional and modern dairy farms, which used maize silage in feed rations, a higher estimated intensity of the methane emission was found in comparison to the farms which did not employ the mentioned type of feed. Also, there was found a very high variability of the parameters of the methane emission as a result of methane fermentation in the particular milk-producing farms (from 0.33 to 0.61 of total variance) what suggests the need of limiting the methane emission. The obtained results revealed a sufficient accordance between the indicators of the methane emission, resulting from the methane fermentation and estimated on the grounds of the analysis of fatty acid profile in milk, and the data coming from the current knowledge, obtained basing on the expensive studies in the respiration chambers. It is however necessary to conduct the further studies with the consideration of other breeds and populations of the dairy cattle, allowing evaluating the meaning of genetic variability and potential of the mentioned phenotypes for utilization in breeding programmes aimed at the reduction of methane emissions.

Less optimistic results were obtained by Van Gastelen Et Al. [2018] who studied the relationships between CH_4 emission and fatty acids and volatile and non-volatile metabolites in milk of the dairy cows. The data coming from six series of the tests of HF cows were utilized; in feeding of the mentioned cows, 27 dietary sets were applied. The nutrition of the cows included a wide range of diets, based upon the feeds differentiated in respect of quality and participation of grass or maize silage. The measurements were conducted in climatic respiration chambers. The following measurements were carried out: methane production (in g per day), yield of methane production (g per one kg of dry matter, DMI) and intensity of methane production (g per one kg of standardized milk in respect of fat and protein content, fat-and protein corrected milk, FPCM). The presence of fatty acids in the milk samples was analysed by the gas chromatography; for volatile metabolites – by the gas chromatography with the application of mass spectrometry and for non-volatile metabolites – by the NMR method (Nuclear Magnetic Resonance). The quantity of dry matter (DM) was equal to 15.9 ± 1.90 kg · day^{-1} (mean ± SD), FPCM yield amounted to 25.2 ± 4.57 kg · day $^{-1}$, CH_4 production – 359 ± 51.1 g · day-1, CH_4 yield – 22.6 ±2.31 g · kg^{-1} DMI and the intensity of CH_4 emission – 14.5 ± 2.59 g · kg^{-1} FPCM.

The results show that the changes in the individual concentrations of milk metabolites may be related to the process of methane production in the rumen. Some of the mentioned relationships were connected with the diet whereas the other ones were partially dependent on FPCM yield. Then, the prediction models were developed and verified basing upon the root mean squared error of prediction (RMSEP), analysis of adaptation coefficient (R2) and random ten-fold cross validation. The best models, describing the correlation between the fatty acid level in milk and methane emission enabled the estimation of production, yield and intensity of the methane emission at RMSEO equal to 34 g · day^{-1}, 2.0 g ·kg DMI and 1.7 g · kg FPCM and values of adaptation coefficient R2 amounting to 0.67, 0.44 and 0.75, respectively. The potential of prediction of the methane emission on the grounds of the separate consideration of volatile as well as non-volatile metabolites was low, irrespectively of the type of the gauge of CH_4 emission. It was supported by the low values of adaptation coefficient R2 (<0.35). The models in which the total level of fatty acids and of volatile and non-volatile metabolites was considered as selective variables, allowed estimating the intensity of methane production at the level of adaptation coefficient = 0.80. The obtained results suggest that the content of volatile and non-volatile metabolites in the milk allows better understanding of methane production process in gastrointestinal tract of the dairy cows. They do not however, justify the measurements of the volatile and non-volatile metabolites as the basis for estimation of methane emission by the dairy cattle. On the other hand, there is a certain potential of utilizing the fatty acid level in milk for estimation of CH_4 emission and in the studies on the better understanding and reduction of the methane emission caused by the dairy cows.

The results of the measurements and estimates of GHG emissions, caused by the animals constitute the basis for verification and updating the indicators, used during the inventory of greenhouse gases in the national scale. The methodology of the National Greenhouse Gas Inventory (NGGI) according to which the GHG emissions in Australia are estimated every year, has been subjected since 1990 to the changes gradually with obtaining the new results of the studies. The change in estimation of GHG emissions connected with milk production, as introduced in 2015 in relation to reporting year 2013 consists in the application of the results of the calculations, employing the Australian Dairy Carbon Calculator (ADCC). In 41 Australian agricultural farms which produce milk with the application of different technologies, the comparative studies of the estimation of GHG emissions using the new method were carried out (being employed the first time in 2015) and the earlier applied method. It was found that the GHG emission intensity, calculated by the newer method, was increased by 3.0%, from 1.05 to 1.07 kg of CO_2 equivalent in terms of the conversion kilogram of milk, considering the protein and fat content. In the spatial system, the declines up to 4.6% were recorded; the maximum increase was up to 10.4%, depending on the region. In the total set of the results of the studies, the increase in methane production from intestinal fermentation as well as from manure management was recorded; on the other hand, the emission of nitrous oxide coming from the manure management as well as CO_2 emission caused by energy consumption and production of nitrogen fertilizers and industrial feeds in the "pre-agricultural" stage (manufacture of agricultural production means). The methane fermentation is still the main source of GHG emissions in animal production, so it will remain the subject of intensive studies. The change in the methodology demonstrated however the meaning of natural manure management and the scientists and the farmers-practitioners will have to pay more attention to the mentioned problem [Christie Et Al. 2018].

The estimation of the methane emissions in the case of one-year old sheep in the national inventory of New Zealand adopts values of the emission intensity indicator at the level of 20.9 g of CH_4 as calculated into one kg of DM consumption by the one year-old sheep. The mentioned data deriving mainly from the studies during which the feed consumption was determined as CH_4 emissions, were indirectly estimated using the sulphur hexafluoride marker. When utilizing the data collected in New Zealand in the years 2009-2015, during which consumption was precisely recorded and CH_4 emissions were measured for at least 48 h in the respiration chambers (n=817), there were updated the algorithms for the estimation of methane production by the sheep; the mentioned values were later recommended to be applied in the national inventory of greenhouse gases. One equation for all age categories of the sheep, based upon the daily methane emission in terms of kg of dry matter consumption (In (g CH_4 $\cdot$day^{-1}) = 0.763 x In (DMI) 3.039) explained 76% of the changes in CH_4 emission. The classification of the data set into two age categories supplied two alternative equations: (sheep>1 year of life), 1n (g CH_4 $\cdot$day^{-1}) = 0.765 x 1n (DMI) 3.09 and (sheep <1 year of life), 1n (g CH_4 $\cdot$ day^{-1} $\cdot$ day^{-1}) = 0.734 x 1n (DMI) + 0.05 (metabolizable energy) + 2.46. The analysis of conformity suggests that the better adjustment of the data is obtained when applying two algorithms. The application of the updated algorithms in the national inventory caused small changes in estimated values of the emissions both in the specified years and between the particular years [Swanson Et Al. 2018].

The pastures are a significant source of methane coming from enteric fermentation but the available techniques for quantitative determination of the level of methane from the mentioned source in the scale of herd are limited. Coates Et Al. [2018] studied the suitability of the system of measuring the eddy covariance for a long term monitoring of CH_4 emission as a result of intestinal fermentation coming from the grazing cattle. The measurements were carried out in two sites: in the middle of a big pasture and in the vicinity of drinking place where the animals were gathering during the day. Location of cattle was monitored by the stop motion technique and the obtained information, together with the application of stochastic model of Lagrange's dispersion were utilized to interpret the stream of eddy covariance and to obtain the indicators of CH_4 emission, as calculated into one animal. The initial measurements on the pastures were difficult due to a quick moving of the cattle within the pasture but the feed supplement place in the direction opposite to the wind blowing helped to keep the animals in the measurement zone. It was found that the methane emissions coming from the cattle in the central part of the pasture were higher and more variable than in the drinking place. When combining the results from the both mentioned places, the methane production at the level of 0.43 g $\cdot$ kg^{-1} of the body weight was obtained; the mentioned value is found within the range of the results reported in other publications, containing the data on the CH_4 emission by the animals present on the pastures. The knowledge of behaviour of the animals staying on the pastures enables the most appropriate distribution of measuring points; together with the application of Lagrange's stochastic model, it may have the practical application during a long-term monitoring of the methane emission in grazing sites.

Amer Et Al. [2018] submitted the methodological assumptions for determination of weight of the factors, considered in determination of the values of indexes applied in the evaluation of the consequences of the selection of breeding animals; its aim is to reduce the level of GHG emission intensity. Factor of GHG emission for breeding purposes was defined as a ratio of the total emission and weighted combination of indicators, characterizing the results of agricultural production. The results of weighting may be employed as linear weights in the way which strengthens the role of all adopted breeding goals before the consideration of the intensity of the greenhouse gases' emission. The calculations, performed with the application of the developed methodology have been utilized in determination of the parameters and definition of assumptions, necessary for linking each change in genetic trait with the expected changes in the GHG emission in animal production. A potential effect of a given trait as calculated into relative number of emitting animals, per one reproduction female, has a direct impact on the level of the emission; the discussed effect is weakened by the production from additional animals. Besides it, each genetic trait may potentially change the level of GHG emission, generated by the animal and, in consequence, affect the level of their production. The discussed methodology has been employed in a form of a simple application in the dairy cattle breeding in Ireland. The profits, resulting from the genetic changes in respect of reduction of greenhouse gases' emission, as assessed with the consideration of the existing tendencies in milk production and fertility and survivability of the cows, were determined. The majority of the profits were identified as causing the increase of milk protein production in terms of one cow, although the profits resulting from the genetic improvement of the survival via the reduction of GHG emission from the herd population were also meaningful.

It was estimated that during the recent 10 years, as result of genetic changes in respect of production, fertility and survival traits, the intensity of GHG emission in Irish milk production has been reduced by ~ 5%. The present acceleration of the trends of genetic changes allows supposing that the reduction of the greenhouse gases' emission by the successive 15% during the coming 15 years may be expected.

Summing up

The animal production in 2015 was a source of 39.8 % of GHG emissions in Polish agriculture, of which 30.7 % came from intestinal fermentation and 9.1% was a result of animal manure management. Due to the fact that the animal production has also its participation in the emission, caused by energy consumption in agriculture, its total share in the total emission of greenhouse gases (GHG) originating in Polish agriculture is equal to ca. 50%.

The emission of the greenhouse gases in animal production is dependent, inter alia, on the animal species, stage of their performance (e.g. age, lactation number), housing system, feeding system, as well as the way of removal and storage of manure which is also a source of harmful emissions.

Dynamically increasing number of the world population causes the increase in the demand on food. Under the conditions of the limited, and in certain parts of the world, the decreasing area of the agricultural land, it is necessary to intensify the agricultural production via the increase of the plant yield and the productivity of farm animals; it is connected with the necessity of increasing the outlays on the production means, and with the increase of the greenhouse gases' emission. In the discussed situation, the need of improving the performance in the agricultural production so as to meet the increasing demand on food all over the world, with the simultaneous minimization of a negative impact on the environment is more and more universally perceived.

The studies of the methane emission as a result of the intestinal fermentation in the animals are carried out in the respiration chambers. Placement of the animals in the mentioned chambers causes the stress what affects the feed intake and, in consequence – CH_4 emission. The results of the direct measurement of GHG emission in the animal production should be therefore treated with a certain caution. Moreover, the measurements of the animal emission of the greenhouse gases are difficult to perform and expensive. Therefore, certain researchers apply the indirect methods for estimation of GHG emissions.

The estimation of the methane emission by the dairy cows by the indirect method may be performed on the grounds of fatty acid profile in the milk, with the utilization of the relationships between the activity of microorganisms in the rumen and the particles available for milk synthesis in the mammary gland.

The results of the measurements and estimates of GHG emission by the animals constitute the basis for verification and updating the indicators, used during the inventory of the greenhouse gases at the national scale.

In the studies on the methane emission, caused by the enteric fermentation taking place during cattle grazing on the pastures, the system of monitoring the animals' movements by the stop motion techniques; the obtained information together with the stochastic model of the Lagrange dispersion is utilized in the interpretation of eddy covariance and in obtaining the CH_4 emission indicators as calculated per one animal. The knowledge of the behaviour of the grazing animal enables the most appropriate distribution of measuring points.

In the evaluation of the consequences of the selection of breeding animals with the aim to determine the parameters and to outline the assumptions necessary for linking each change in genetic trait and the changes in the intensity of GHG emission in the animal production, the method of the weights of the factors considered during the determination of the indicators, used in the calculations, is utilized.

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