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Methods for Determining the Release of Greenhouse Gas Emissions from Pig and Poultry Production in the Republic of Bulgaria

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The proposed methodology is universal and it could be a basis for designing and filling in electronic tables and visual programs (algorithms) for electronic processing and visualization of the summarized data. It could be used as a basis for synchronizing calculations of the greenhouse gas emissions from manure in pig and poultry breeding on a regional or international level.

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Methods for Determining the Release of Greenhouse Gas Emissions from Pig and Poultry Production in the Republic of Bulgaria

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I. Introduction

Following the implementation of the decisions of 18th annual session of the Conference of the Parties to United Nations Framework Convention on Climate Change, Doha, extending the life of the Kyoto Protocol, the precise determining of the emissions from different anthropogenic sources of pollution, i.e. industry, agriculture, household waste, etc., has acquired still greater importance. A number of Bulgarian, European and International documents (Section A in the References) confirm those issues. Problems treated are of importance for both determining the country quotas and the emission trading schemes and for setting objective pollution parameters when establishing and operating different economic units – industrial enterprises, agricultural farms and waste-treatment plants.

Major pollutants on livestock farms are biological wastes (dung and urine) and the released rumen and intestinal gases (Goodland and Anhang, 2009; Petrov et al., 1983; Dinev et al., 2009). In the Report of FAO entitled "Livestock's Long Shadow reads that annually, 7516 million tons of CO2 equivalent (18%) of all the greenhouse gases result from breeding cattle, buffalos, sheep, goats, camels, horses, pigs and domestic poultry, which puts their breeding under question. A similar analysis of those statements, made by Good land and Anhang (2009), confirmed that the annual contribution of animals and by-products is about 32564 million tons of CO_2 emissions, which is more than half of all the greenhouse gases from human activities.

Statistical data of the Republic of Bulgaria are based on sporadic or periodic reports on the number of animals in the country, hence the evaluation of the polluting substances is difficult and of low precision. Contrary to breeding ruminants, the formation and release of intestinal gases in pig and poultry production is extremely low and they are disregarded in the evaluation of harmful emissions.

The aim of the present study was to develop methods accurate enough to evaluate the greenhouse gases on the basis of the available statistical data about the number of the animals, which could be applied not only in the formal country statistics but also in any poultry and pig production enterprise.

II. Material and Methods

a) Basic Data Needed for Input to the Model

i. Mother Sows

Each year 2, 4 pig litters are produced by a sow in average, the pregnancy continuing for 114 days and the period of lactation – 28 days (following the standards for industrial pig breeding). A week after weaning the piglets, the sows come into heat and are inseminated again. The period between weaning and insemination is registered as the period of pregnancy because the feeding rate is the same, i.e. the mother sows receive the same daily amount of forage as the pregnant ones (by Stoykov, Katsarov, 2010). Consequently, during a year period, each sow is in a period of pregnancy for 298 days and in a period of lactation for 67 days.

ii. Growing and fattening pigs

Their number is calculated by deducting the number of the mother sows from the total number of pigs. Only fattening pigs are taken in the formula, because the pigs for breeding stock are a very small percentage of all the pigs and their digestible energy /DE/ intake does not differ considerably from that of fattening pigs. However, the total number of pigs during the year (growing and fattening) are reported when determining the greenhouse gases.

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iii. *Hen species*

The information given below refers to hens only, as their number is over 90% of all the poultry species reared in Bulgaria.

iv. *Laying hens*

-Data about the three most widely spread laying-hen hybrids in Bulgaria.

(Source: http://www.isapoultry.com)

Stock hybrid	Forage consumption per hen, 1-126 days of age, kg	Average daily consumption, 1-126 days of age, g	Forage consumption, 19 to 90 weeks of age, kg	Average daily consumption, 19-90 weeks of age, g	Number of eggs	Egg mass hen housed, kg
Hisex brown	6,6	52,4	55,6	112	408	25,6
Bovans brown	6,6	52,4	56,9	114	408	26,0
ISA brown	6,6	52,4	55,2	111	409	25,7

-Data about laying hens (calculations are based on data by Kabakchiev, Aleksieva, Genchev, Nikolova, Gerzilov, 2014, Poultry farming – textbook – in print):

Basic consumption of compound feed – egg-laying branch – 0,112 kg per day

Basic consumption of compound feed – parents, broiler production – 0,170 kg per day

Basic dry matter in 1 kg of compound feed – 88 %

Basic GROSS ENERGY in 1 kg dry matter of feed – 18, 45 MJ/kg (for hens and fattening broiler chickens)

Fattening chickens (broilers)

v. *Standards*

For the gross energy in 1 kg of dry matter, content of dry matter in 1 kg of feed – the same as for hens.

Metabolizable energy in 1 kg of feed (by Kabakchiev, Aleksieva, Genchev, Nikolova, Gerzilov, 2014, Poultry farming – textbook – in print) – ranging between 12, 85 and 13,50 (average 13,3 MJ + 4% = 13,854/0,88 = 15,74 MJ/DIGESTIBLE ENERGY/kg of dry matter).

In our country the growing cycle of a broiler chicken is 42 days in average (a standard). The consumed feed mixture for that period is 4, 51 kg in TOTAL (COBB standard + 10% added for real production conditions).

Additional information for fattening chickens (for the correct determining of the total amount of volatile substances per year)

-Number of produced broilers (S×ource: An×nual Agricultural Report of the Ministry of Agriculture and Foods, 2013).

Number of chickens for meat at the end of the year, in thousands (for a fattening cycle).

2010	2011	2012	In average for the three years
6263	6522	7499	6761

III. Results and Discussion

a) Choosing the mathematical models (formula)

Following a preliminary assignment, the formula chosen and modified by us, is: (http://www.ipcc-nggip.iges.or.jp/public/gp/english/4_Agriculture.pdf/p.31):

$VS = (DMI \times 18.45) \times (1\text{-}DEI/100) \times (1\text{-}\%ASH/100)$

Where: VS – volatile solid excretion per day on a dry matter weight basis, kg DM/day

DMI – dry matter intake (kg(g)/animal for 24 hours 18.45 (MJ/kJ) – mean gross energy content in 1 kg(g) dry matter DEI (MJ/kJ) – digestible energy intake – by 1 animal for 24 hours (as coefficient (percentage) from the gross energy intake) % ASH – percentage of ash content in DM of the excrements.

i. *Choosing models for filling in data for pigs*

The annual statistical data of Bulgaria contains the characteristics "total number of pigs" and "out of them, mother sows". The number of growing pigs plus fattening pigs is obtained by deducting the number of mother sows from the total number of pigs.

b) Mother sows

i. *Pregnant sows*

A pregnant mother sow consumes 2, 9 kg of feed mixture/24 hours in average, i.e. 298×2,9=864 kg annually. The standards about the dry matter content in the feed mixtures (for all the categories of pigs and poultry) is 88%, which means that a pregnant sow consumes 760, 5 kg of dry matter annually. The digestible energy content in 1 kg of dry matter for pregnant sows is 14, 32 MJ in average, standard (NRC-2010, Todorov et al., 2010), i.e. a pregnant sow receives 10890 MJ of digestible energy annually.

The amount is increased by 10% for boars (not included in statistical data), as their daily consumption of digestible energy is the same as of pregnant sows and they represent about 8% of the mother sows

(consequently, the digestible energy is 12100 MJ per mother sow).

The GROSS ENERGY intake from the feed for pregnant sows is: 760, 5×18,45=14031 + 10% = 15590 MJ

12100/15590=77,6% or the level of energy metabolism in the formula is 0,7761.

Data about pig excrements, described below, are based on own studies and they represent the reported average values of 6 samples of different origin – pig-fattening farms.

Pig dung (without urine) – taken by Ampula recti for pigs – 110 kg from slaughter-houses – pure (without being in contact with the floor):

Average relative weight of 1 dm3 – 0,962 kg

Average dry matter content – 24,50%

Average content of CRUDE ASH in DRY MATTER – 12,21% (0,1221 in the formulae for all the pig categories).

The formula for pregnant sows is: VS = 15590×(1-0.7761) × (1-0.1221)

ii. *Lactating sows*

Following the standard, a lactating sow consumes 6, 8 kg×0, 88 = 6 kg of dry matter/24 hours.

Following the standard, 15, 9 MJ of digestible energy is contained in 1 kg of dry matter.

15, 9×6×67=6392 MJ annual digestible energy consumption

GROSS ENERGY intake from forages for pregnant sows is: 6 × 67 × 18, 45 = 7420 MJ

6392/7420 = 86, 15% or the degree of energy metabolism in the formula is 0, 8615

The formula for lactating sows is: VS = 6392 × (1-0.8615) × (1-0.1221)

iii. *The average DAILY amount of the volatile gases produced by a sow*

-Summing up the final figures obtained for the two periods – pregnancy and lactation;

-The sum is divided in 365 (the number of days of the cycle, which is one year).

c) Growing pigs

Their number is calculated by deducting the number of mother sows from the total number of pigs. Only fattening pigs are taken as a basis because the young pigs raised for breeding stock are a very small percentage of all the pigs and their intake of digestible energy does not differ considerably from that of fattening pigs.

Data calculated below are obtained using the basic data by Todorov et al., 2011 and Stoykov, Katsarov, 2010).

Digestible energy intake

1.3. Until 28th day – 558 MJ DM/pig in total for the whole period, BUT ONLY FROM FORAGE. It is admitted that DE consumption from the sow's milk adds 50% additional energy consumption but it could not be measured precisely. ADDITIONALLY, THE ASH SUBSTANCES (as well as all the substances contained in milk) ARE ABSORBED AT OVER 98% and only insignificant amounts remain in the dung of piglets. That is why we increase only the coefficient of digestibility in the formula.

Gross energy: 649 MJ for the whole period

Absorption level – 92% (it is the arithmetic mean between the absorption from the sow's milk– 98% and from the starter mixture – 86%).

The formula for the category is: VS=649 × (1-0.92) × (1-0.1221)

2.3. 10-30 kg live weight – 0,5 kg weight gain in average = 40 days×1,05×0,88×16,14 = 597 MJ/pig for the whole period

Gross energy – 1, 05 × 0, 88 × 18, 45 × 40=682 MJ/pig for the whole period, or 597/682=87, 54%, or 0, 8754.

The formula for the category is: VS=682 × (1-0.8754) × (1-0.1221)

3.3. 30-60 kg live weight, 0, 8 kg weight gain = 38 days× 1, 95 ×0, 88 ×15, 7 = 1024 MJ/pig for the whole period

Gross energy: 38× 1, 95× 0, 88 ×18,45 = 1203 MJ

1024/1203=85% or 0, 85 for the formula.

The formula for the category is: VS=1203 × (1-0.85) × (1-0.1221)

4.3. 60-90 kg at 1 kg of gain weight = 60 days × 2, 60 × 0, 88 × 15 = 2059 MJ/pig for the whole period

Gross energy: 60 × 2, 60 × 0, 88 ×18, 45=2533 MJ or 2059/2533 = 81% or 0,8 1 for the formula.

The formula for the category is: VS=2533 × (1-0.81) × (1-0.1221)

5.3. 90-120 kg, 0, 9 kg weight gain = 33 days× 2, 9 ×0, 88 ×14, 55 = 1225 MJ/pig for the whole period

Gross energy: 33 ×2, 90 ×0, 88 ×18, 45=1554 MJ or 1225/1554 = 78, 8% or 0, 788 for the formula.

The formula for the category is: VS=1554 × (1-0.788) × (1-0.1221)

**Note: In Bulgaria pigs are fattened to a live weight of 120 кg. It is not a problem to re-calculate the average daily excretions to a final live weight of 90 kg and in that case the periods become 4 instead of 5.*

d) Calculating the average daily excretions of a growing/fattening pig

-Summing up the figures for ALL the periods (either4 or 5);

-The sum total is divided by 166 or 199 (the days of the cycle for pigs, which is less than a year).

Choosing models for filling in data for poultry

i. *Basic data from own studies on some characteristics of poultry manure*

Poultry excrements (dung plus urine) – 6 samples of different origin – farms for egg-laying hens (cage breeding), pure (collected immediately)

Average relative weight of 1 dm3 – 0, 7778 kg

Average dry matter content – 26, 75%

Average content of CRUDE ASH in the DRY MATTER – 18, 48% (0, 1848 for the formula)

Fattening chickens:

Average relative weight of 1 dm3 – 0, 7778 kg

Average dry matter content – 26, 75%

Average content of CRUDE ASH in the DRY MATTER – 12, 63% (0, 1263 for the formula)

The difference between hens and chickens in the ash content is due to the fact that the feed for laying hens contains 3-4 times more ash (mainly calcium salts) and although the hens assimilate salts better than the broilers, still their excrements contain more undigested ash substances.

ii. *Laying hens*

According to the standard, the average metabolizable energy in mixtures for laying hens for both production branches is 11, 5 MJ/kg (variations being within 11, 3 to 11, 9).

11, 5/0, 88 (dry matter content in the forage) = 13, 07 MJ ME/kg of DRY MATTER+4% = 13, 62 MJ DIGESTIBLE ENERGY FOR POULTRY/kg of dry matter

Hens for broiler production are about 15% of the total number of laying hens, so 0, 112×0, 85+0, 17×0, 15=0, 119 kg/day/layer (for egg and egg-broiler production);

0,119×0, 88 = 0, 105 kg of dry matter is consumed by a layer for a 24-hour period.

Statistical data contains the total number of layers and growing layers, however, according to statistics, a growing layer consumes 7 kg of forage in average for 18 weeks. The amount in the table is 6, 6 kg, approximated to 7 kg, because in the Republic of Bulgaria 5-6% increase is realistic, because the standard could not be reached (7 ×0, 88 = 6, 16 kg of dry matter). After that the growing hen starts laying eggs and it enters the category of layers. Summarized, it means that the hens are growing layers for 126 days and they consume 0, 049 kg of dry matter for a 24-hour period in average.

The whole productive period of the layers (from hatching through growing layers, laying and culling out) continues for 630 days.

630-126 = 504 days of laying × 0, 105 kg daily consumption of dry matter

504:630 = 0, 8 relative share

126/630 = 0, 2 relative share

0, 8 × 0,105+0, 2 × 0,049 = 0,094 kg OF DRY MATTER IN AVERAGE per layer each day of its life from hatching to culling out.

0, 094 ×18, 45=1,73 MJ GROSS ENERGY FOR THE FORMULA

0,094 ×13, 62=1, 28 MJ DIGESTIBLE ENERGY

1, 28/1, 73= 74, 01% digestibility or 0, 7401 for the formula

The formula for the category is: VS = 1, 734× (1-0.7401) × (1-0.1848)

iii. *Broiler chickens – calculations are done on the basis of data in the section "Material and Methods"*

6761000 ×6, 5 fattening cycles = 43946500 – total number of fattened broilers produced annually. However, those broilers have not released excrements for 365 days in the year, but:

6, 5 ×42 (only during the fattening period) = 273 days (in the rest of the days the premises were empty for disinfection and cleaning….).

Data are recalculated for one broiler chicken of COBB hybrid – the most widely-spread fattening hybrid in our country.

4, 51/42 = 0, 107 kg forage ×0, 88 = 0, 094 kg DRY MATTER daily

0, 094 ×18, 45 = 1, 737 MJ gross energy

0, 094 ×15, 74 = 1, 48 MJ digestible energy

1, 48/1, 737 = 0, 852 level of digestibility.

The formula for the category is: VS = 1, 737× (1-0.852) × (1-0.1263)

IV. Additional Information

The above-given calculations could be used ONLY for industrial-scale pig-breeding and poultry farms. Objective information for the standard intake, utilization of forage energy and chemical analysis of the excrements could not be collected in private yards.

V. General Conclusions

The presented methods are universal and they could be a basis for designing and filling in electronic tables and visual programs (algorithms) for electronic processing and visualization of the summarized data. Other major parameters (duration of the production cycle, forage consumption rate, etc., applicable for practice in the different countries and regions) could also be included in the calculating algorithms.

The method could be used as a basis for synchronizing calculations of the greenhouse gas emissions from manure in pig and poultry breeding on a regional or international level.

The method could also be used for calculating emissions for evaluation reports about the environmental impact when establishing new or reconstructing existing pig and poultry breeding farms.

VI. Acknowledgements

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