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METHODS OF CALCULATING THE EMISSIONS OF ENVIRONMENTAL POLLUTANTS FROM PIG MANURE WASTES IN BULGARIA

МЕТОДИКА ЗА ИЗЧИСЛЯВАНЕ НА ЕМИСИИТЕ НА ЗАМЪРСИТЕЛИ НА ОКОЛНАТА СРЕДА ОТ ТОРОВИ ОТПАДЪЦИ ОТ СВИНЕВЪДСТВОТО В БЪЛГАРИЯ

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Abstract

An attempt was made to systemize the data and to develop a methodology for a reliable evaluation of the nitrogen emissions and other ecological pollutants from pig manure wastes in the Republic of Bulgaria.

The authors find the suggested methodology to be precise enough and easy to be managed as it combines the use of the available official statistical sources and the possibility of its integration into comparatively popular software products (EXCEL). The methodology could be taught in practical seminars for students and specialists in the area of agroecology.

Keywords: emissions, manure wastes, pig-breeding

Резюме

Направен е опит за систематизиране на данни и изграждане на методическа постановка за обективно отразяване на емисиите на азот и други екологични замърсители в природата от торови отпадъци в свиневъдството в Република България.

Авторите считат, че предложената методика е достатъчно точна, и лесна за управление, поради факта, че комбинира използването на наличните официални статистически източници с възможността, за въвеждането и в сравнително достъпни софтуерни продукти (EXCEL). Методиката може да бъде ползвана успешно и в практическите занятия на студенти и специалисти в областта на агроекологията.

Ключови думи: емисии, торови отпадъци, свиневъдство

Detailed abstract

The problem with the precise determination of the environmental pollutants from pig manure wastes is of primary importance to the EU member states, because of the higher concentration of livestock.

The precise methodological determination of the emissions from manure wastes helps the national statistics, on the one hand, and, on the other – it guarantees reliability and precision of the presented reports, thus raising the prestige of our country as a loyal Community member.

The aim of the present investigation was to offer a common methodology for calculating the emissions of environmental pollutants from pig manure wastes on the territory of the Republic of Bulgaria, based on reliable statistical and scientific sources of the recent years.

Data about the number of pigs is available from the national statistics. Summarized data about the number of pigs in the Republic of Bulgaria were used - following [11, 12].

Calculations are offered for the lacking data, based on the most proper interrelations between the basic characteristics of the different categories of pigs. The data from the latest research studies in Bulgaria have been used.

The percentage distribution of the concentration of the major animal groups in the pig-breeding farms is based on the authors' observations. The ways of storing and managing the manure wastes are presented in accordance with the European Commission requirements.

The authors conclude that the proposed methodology is precise enough (it uses reliable statistical data from the national statistics and the latest Bulgarian studies). It is very simple and clear and the mathematical calculations could be

integrated into popular and widely used software packages (Excel, for example). It could be successfully applied in practical seminars for students and specialists in agroecology.

Детайлно резюме

Проблемът с точното определяне на емисиите на замърсителите на околната среда от оборския тор от особена важност за страните от Европейския съюз, поради високата концентрация на селскостопански животни.

Методически точното определяне на емисиите от торовите отпадъци от една страна помага на националната статистика, а от друга, дава надеждност и

точност на представените доклади, което спомага за повишаване на имиджа на България като лоялен член на общността.

Целта на настоящата разработка е, да се предложи единна методика за изчисляване на емисиите на замърсители на околната среда от свински тор, на територията на Република България, на базата на достоверни статистически и научни източници през последните години.

Данните за броя на свинете могат да се вземат от националната статистика. В настоящата разработка са ползвали обобщени данни за числеността на свинете в РБългария – по [11, 12].

За липсващите данни са предложени изчисления, основаващи се на възможно най - точни зависимости между основните показатели за различните категории свине. Ползвани са и базисни данни от най – нови научни опити в България.

Процентното разпределение на концентрацията на основни животни в свинефермите е направено на база собствени наблюдения на авторите, а начините на съхранение и мениджмънт на торовите отпадъци са посочени съгласно изискванията на Европейската комисия.

Авторите заключават че предложената методика е достатъчно точна (ползва достоверни статистически данни от националната статистика и най – съвременни български изследвания), същата е достатъчно опростена и ясна и може да се въведе като математически действия в сравнително познати и употребявани софтуерни пакети (например EXCEL) и може да бъде ползвана успешно и в практическите занятия на студенти и специалисти в областта на агроекологията.

INTRODUCTION

The problem with the precise determination of the environmental pollutants from pig manure wastes is of primary importance to the EU member states, because of the higher concentration of livestock. That is why the European Commission has set a requirement to the member states, including Bulgaria, to prepare annual reports for developing the further strategic aims and priorities, such as setting emission quotas, working out the directives in the area of ecology, etc.

The precise methodological determination of the emissions from manure wastes helps the national statistics, on the one hand, and, on the other – it guarantees reliability and precision of the presented reports, thus raising the prestige of our country as a loyal Community member.

Pig manure is one of the most aggressive agricultural wastes. The countries with a higher concentration of pig breeding farms (Denmark and the Netherlands) have developed overall ecological pig manure management tools. In Denmark, the Danish Animal Manure Normative System has been worked out, which played the major role

for the introduction of the EC Directive 2008/1/EC – IPPC – Integrated Pollution Prevention and Control. It set common rules for all the EU member states [1, 11]. As an EC member Bulgaria is not an exception, referring to the legislation on environmental protection. A methodology was developed for conducting an integrated ecological assessment of the anthropogenic ecosystems in pig breeding and the level of their effect on the environmental components [7, 9] et al.

The aim of the present investigation was to offer a common methodology for calculating the emissions of environmental pollutants from pig manure wastes on the territory of the Republic of Bulgaria, based on reliable statistical and scientific sources of the recent years.

MATERIAL AND METHODS

Data about the number of pigs is available from the national statistics. Summarized data about the number of pigs in the Republic of Bulgaria were used (following [11, 12] – Table 1.

Table 1. Number of pigs in Bulgaria in different years and the distribution according their concentration in one production unit. Таблица 1. Брой на свине в България през различни години и разпределението им по концентрация в производствена единица:

Years/Години	Total number of pigs/ Общ брой свине	Sows/ Свине - майки	Piglets under 20 kg LW/ Прасета до 20 кг ЖМ*	Piglets 20-50 kg LW/ Прасета 20-50 кг ЖМ*	Pigs 50-80 kg LW/ Прасета 50-80 кг ЖМ*	Pigs 80-110 kg LW/ Прасета 80-110 кг ЖМ*
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1992	2 680 000	271 000	529 980	710 655	674 520	590 205
2000	1 546 000	164 000	304 097	407 767	387 032	338 654
2005	943 000	96 500	186 230	249 718	237 020	207 393
2010	783 000	71 400	156 552	209 922	199 248	174 342

*Recalculation of the number of pigs in the separate categories was made following the scheme: calculating the mean number of days for the pigs to reach the final slaughter weight (according to the average daily gain in weight for each category - [13, 14]. The number is divided to 365 to find the correction coefficient. The sum of the correction coefficients should be approximately 1. The difference between the total number of pigs and the number of sow mothers is multiplied by the coefficient for finding the number of pigs in each category.

For example: The total number of pigs in 1992 (total number of pigs minus sows) = 2409000. The daily gain in weight of the category of 0-20 kg live weight (LW) is 0,25

kg, reaching 20 kg of live weight in about 80 days in average. 80/360 = 0,22 (correction coefficient). 2409000 x 0,22 = 529980 (column 4 – line 3).

The percentage of dropped out animals, varying within 5 for suckers and 2 for pigs over 80 kg LW, could be included in the calculations for a better precision in determining the number.

Data from sources cited in the discussion of the present paper were used for all the further calculations.

RESULTS AND DISCUSSION

For the amount of manure and urine released by sows, the average data of the studies of [10] and [8] were used and the data about grower pigs were taken following the studies of [2,3,4,5] – Table 2.

Table 2. Mean amounts feces and urine, so as nitrogen from different categories of swine.
Таблица 2. Осреднени количества фекалии, урина, както и азот от различни категории свине:

Categories of swine/ Категории свине	Separated feces – kg/24 hours/ Отделени фекалии – кг/ денонощие	Separated urine – kg/24 hours/ Отделена урина – кг/ денонощие	Separated nitrogen with feces – kg/24 hours/ Отделен азот с фекалии - кг/ денонощие	Separated nitrogen with urine – kg/24 hours/ Отделен азот с урина – кг/ денонощие
(1)	(2)	(3)	(4)	(5)
Sows/ Свине – майки	3,06*	4,94*	0,016	0,035
Piglets under 20 kg LW/ Прасета до 20 кг ЖМ**	0,17	0,34	0,0016	0,0026
Piglets 20-50 kg LW/ Прасета 20-50 кг ЖМ	1,02	2,03	0,0095	0,016
Pigs 50-80 kg LW/ Прасета 50-80 кг ЖМ	1,51	2,80	0,011	0,026
Pigs 80- 110 kg LW/ Прасета 80-120 кг ЖМ	1,74	2,83	0,0114	0,032

Only the nitrogen content in excrements was given in the table, for presenting the methodology in a more simple way. The average amounts of the excreted phosphorus, calcium and other biogenic elements that are of interests for the statistics, could be found in the same literature sources.

* For establishing the average amounts of feces and urine of sows, the following calculations were made: following the cited literature sources (7 kg of excrements per pregnant sow and 12 kg per feeding sow) it was accepted that during the year the sows are pregnant (or provisionally pregnant) for 300 days in average and for 65 days are feeding the piglets. The correction coefficient according to the number of days in the year are 0,82 (300/365) and 0,18 (65/365), respectively. The amounts established are multiplied by the coefficients and their sum is the average daily excretes (8 kg). Feces/urine ratio is 1:0,62 [10] and after calculation, it makes 4,94 kg of feces and 3,06 kg of urine. Nitrogen in the sow feces is 0,52% in average and in the urine – 0,71% .

** For all the categories of pigs over 20 kg LW we have used data from the above-mentioned sources and for the category of pigs up to 20 kg LW we have done recalculations based on the ratio coefficient (RC) between the average live weights of the categories 50-80 kg (65 kg) and up to 20 kg (average LW – 10,75 kg). In the present case, RC = 0,165 (10,75/65) and we use it for correcting the released amounts of excrements and nitrogen.

Data in Table 3 are partially based on the information of the national statistics (following [12] and on the expert opinion of the authors, drawn after many-year observation during their visits throughout the country.

The following scheme was adopted:

1. It is conventionally admitted that all the pig-breeding farms, having up to 10 sows (small private farms) collect the mixed excrements for a long time in their own yards WITHOUT SPECIAL SITES – JUST IN THEIR OWN YARDS, the manure is stored for several months and as the manure decays, it is used for fertilizing. Thus pollutants are freely released both into air and soil and (eventually) into ground waters. Such farms have the highest risk of environmental pollution.

2. In all the farms having 10-50 sows, the manure is collected as semi-solid waste on CEMENTED GROUNDS, where it is stored FOR MONTHS and AFTER THAT IT IS USED FOR FERTILIZATION. Thus, only emissions into the air are released. Such farms carry a moderate to considerable risk of environmental pollution.

3. All the farms having over 50 sows, store the manure in anaerobic BUT OPEN LAGOONS where the manure stays for 30-200 days. As the lagoons are open deep cemented basins without additional aeration or microbiological processing, the emission gases are released into the atmosphere from the upper layer of the fecal mass only. Such farms could be categorized as units of a moderate to low risk of environmental pollution.

At present the other ways of manure processing (closed anaerobic lagoons, biogas installations, etc.) represent an insignificant percentage of the total management of the manure wastes from pig breeding farms.

In the last years the data about the percentage ratio of the farms of various size, have been summarized in the national statistics.

We put the problem to the attention of the competent authorities at the Ministry of Agriculture and Foods and the Ministry of the Environment and Waters for adding the data in the Statistical Yearbooks as the information is a valuable source not only on the problem discussed but also for calculating the average capacity of the livestock farms in our country.

Table 3. Distribution of the producing units according the producing capacity (acc. [11, 12])
Таблица 3. Разпределение на стопанствата според капацитета на производство (по [11,12]):

Years/Години	Percentage of the housed swine in units (farms) under 10 sows/ Процент на отглеждани свине в стопанства до 10 свине – майки	Percentage of the housed swine in units 10-50 sows/ Процент на отглеждани свине в стопанства от 10 до 50 свине - майки	Percentage of the housed swine in units over 50 sows/ Процент на отглеждани свине в стопанства над 50 свине – майки
(1)	(2)	(3)	(4)
1992	8	0	92
2000	35,5	17,5	47
2005	33	13,5	53,5
2010	15	6,5	78,5

Table 4 presents the calculated data and some explanations about the distribution of nitrogen as the major pollutant contained in manure. Calculating the other manure elements follows the same principle.

Table 4. Main data for calculation of yearly yield of excrements and pollution – imissions from sow-breeding in Bulgaria/Таблица 4. Основни данни за изчисляване на годишното количество екскременти и имисии на замърсители от свиневъдството в България:

Years/ Години	Nitogen yield from feces- kg/ year/ Получен азот от фекалии – кг/год	Nitogen yield from urine- kg/ year/ Получен азот от урина – кг/год	Total nitogen yield from feces+urine kg/year/ Общо получен азот от фекалии и урина	Amount (kg) nitrogen entering in soil and air/ Килограми азот, попадащ в почвата и въздуха	Amount (kg) nitrogen deposed on concrete grounds/ Килограми азот, попадащ на обикновени циментови площадки	Amount (kg) nitrogen deposed in opened anaerobic lagoons/ Килограми азот, попадащ в открити анаеробни лагуни
(1)	(2)	(3)	(4)	(5) *	(6) **	(7) ***
1992	9520385	21409990	309303375	2474430	0	28455945
2000	5512357	12590235	18102592	6426420	3167954	8508218
2005	3352812	7539543	10892355	3594477	1470468	5827410
2010	2759644	6213827	8973471	1346021	583276	7044175

Figures in column (2) are the sums of the products of the number of pigs in the respective categories presented in Table 1, multiplied by the number of days in the year (365) and by the amounts of nitrogen released from the feces for a dayand night.

Figures in column (3) are the sums of the products of the number of pigs in the respective categories presented in Table 1, multiplied by the number of days in the year (365) and by the amounts of nitrogen released from the urine for a day and night.

* The total amount of nitrogen (4) is multiplied by the percentage of the pigs raised on farms having up to 10 sows (Table 3).

** The total amount of nitrogen (4) is multiplied by the percentage of the pigs raised on farms having 10 to 50 sows (Table 3).

*** The total amount of nitrogen (4) is multiplied by the percentage of the pigs raised on farms having over 50 sows (Table 3).

We think that referring to nitrogen emissions, separate calculations should be made for the urine and for the feces, as urine nitrogen is more direct pollutant of the pig-breeding premises and the actual data about its release will help developing more precise schemes for its inactivation.

CONCLUSIONS

The proposed methodology is precise enough (it uses reliable statistical data from the national statistics and the latest Bulgarian studies).

Concerning the possibilities of its application, we think that it is very simple and clear and the mathematical calculations could be integrated into well-known and widely used software packages (Excel, for example), which makes it convertible not only in Bulgaria but worldwide (including the European Union).

The methodology could be successfully applied in practical seminars for students and specialists in agroecology.

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