

## **DATABASE SYSTEM FOR ACQUISITION AND DATA PROCESSING ON AIR POLLUTION FROM AGRICULTURAL PRODUCTION**

### *Summary*

*Agriculture is the source of gaseous, particulate matter emissions and the livestock production also generates the problem of odor nuisance. To monitor and evaluate the scale of its environmental impact are used dedicated database systems which function is collection, processing and visualization of data. The aim of the study was to design and make the database system "Agricultural Air Pollution. Acquisition and Data Processing System" for monitoring air pollutions from agricultural production. It is used to collect, process, report and analyze data. The main function of the system is the calculation of gases ( $CH_4$ ,  $N_2O$ ,  $NH_3$ ), particulate matter ( $PM_{2.5}$  and  $PM_{10}$ ) and odors emission from agricultural production. Gas and particulate matter emissions are calculated on the basis of available, international and self-developed methodologies, while the odor emissions based only on self-developed methodology. It will be possible to determine own specific emission factors for Poland, using the collected data. In the future, the system may provide an extensive database and be useful to verify the cyclic reports of greenhouse gases and particulate matter emission from agriculture. This knowledge may be helpful under developing national strategies for this sector.*

**Key words:** database system, agriculture, air pollutant, odor

## **SYSTEM BAZODANOWY DO AKWIZYCJI I PRZETWARZANIA DANYCH O ZANIECZYSZCZENIACH POWIETRZA Z PRODUKCJI ROLNICZEJ**

### *Streszczenie*

*Rolnictwo jest źródłem emisji zanieczyszczeń gazowych i pyłowych, a produkcja zwierzęca dodatkowo generuje problem uciążliwości zapachowej. Do monitorowania i oceny skali oddziaływania na środowisko wykorzystuje się dedykowane systemy informatyczne, których zadaniem jest kolekcjonowanie, przetwarzanie oraz wizualizacja danych. Celem pracy było zaprojektowanie i wykonanie systemu bazodanowego „Rolnicze Zanieczyszczenia Powietrza. System Akwizycji i Przetwarzania Danych” służącego do monitorowania zanieczyszczeń powietrza z produkcji rolniczej. Przeznaczony jest on do gromadzenia, przetwarzania, raportowania oraz analizy danych. Głównym zadaniem jest obliczanie emisji gazów ( $CH_4$ ,  $N_2O$ ,  $NH_3$ ), pyłów ( $PM_{2.5}$  oraz  $PM_{10}$ ) i odorów. Emisje gazów i pyłów wyliczane są na podstawie metodyk międzynarodowych i własnych, natomiast dla odorów oparto się tylko na metodyce własnej. Pozwoli to na wyznaczenie własnych współczynników emisji gazów, pyłów oraz odorów, które będą uwzględniać charakterystykę polskiego rolnictwa i odzwierciedlać jego specyfikę. W przyszłości system może stanowić obszerną bazę danych i być przydatny do weryfikacji okresowych sprawozdań w zakresie emisji gazów i pyłów z tego sektora gospodarki. Wiedza w tym zakresie może być pomocna przy opracowywaniu krajowych strategii dotyczących rolnictwa.*

**Słowa kluczowe:** system bazodanowy, rolnictwo, zanieczyszczenie gazowe, odory

### **1. Introduction**

The negative impact of agriculture on the environment is associated with the progressive intensification. The effect of it is the large concentration of livestock production, exceeded livestock density and intensive use of mineral fertilizers [3, 6]. In the European Union, including in Poland, agriculture, is the second largest, after the energy sector, source of greenhouse gas (GHG) emissions. According to the report of the National Centre for Emissions Management share of this sector in national GHG emissions is estimated at 34% for methane and 84% for nitrous oxide [8]. Besides agriculture emits significant amounts of ammonia. The share of agriculture in the total ammonia emissions in the EU countries amounted almost 94% in 2010 [2]. In Poland, 98% of total ammonia is emitted from agricultural sources and 70% of it is from animal production. [9].

The constant anthropogenic pressure tends to take various initiatives aimed at limiting its effects and environmental protection. It is necessary to carry out continuous

monitoring of the environment and take activities at the international level like: The United Nations Framework Convention on Climate Change [14], The United Nations Convention on Long-range Transboundary Air Pollution [13]. One of the tools used to collect data from environmental monitoring are databases [7].

The aim of the study was design and make the database system "Agricultural Air Pollution. Acquisition and Data Processing System" used for monitoring gas, particulate matter and odor emissions.

### **2. Database system**

Database system "Agricultural Air Pollution. Acquisition and Data Processing System" was designed and made by the Institute of Technology and Life Sciences, Poznan Branch in cooperation with Madar Ltd. The system was performed under the Multiannual Programme for 2011-2015 "Standardization and monitoring of environmental projects, agricultural technology and infrastructure solu-

tions for security and sustainable development of agriculture and rural areas", Section 1.4 "Monitoring of odors and air pollutants emission from agricultural sources, including particulate matter and gas emissions". The system allows the collection, processing, reporting and analysis of data related to the monitoring of air pollution from agriculture.

### 3. System description

The system is the relational database built on SQL server. It is a closed application, based on the internal format of data storage, which reduces the risk of external unwanted access into the database.

The organization of the system can be separated into the logical and physical structure. The logical structure consists of the following elements:

- data collection,
- data processing,
- data presentation.

The physical structure provides access to the system, which is possible using a web browser. The application allows free access to the system for all users at the same time, from any location, while maintaining data integrity and security.

Using the database system is restricted. Access is possible after logging on the system website, using a web browser (Fig. 1). There are two independent groups of users. The first is advanced users and system administrators. This group can manage the system and parameterize and configure the basic parameters of the program, such as the attributes of entities, a list of vocabulary and individual data sets. The second is the users who have the ability to input and preview the data in the system [11, 12].

In separated databases are stored unprocessed and processed information, because the data entered into the system have a different form than the data presented. This provides easier access, better control over data security and increased access to information contained in the system.

### 4. System properties

Designed database system has many properties that provide its functionality, easy to use and correct operation. One is scalability, which ensures optimal system performance depending on its load. The system can work together with

many external devices, among others: printers, cheap card readers, scanners and the following programs: Microsoft Word, Open Office (create documents based on templates), Microsoft Excel (export and presentation of reports), Adobe Acrobat (export reports in PDF format). The supported file formats are: XML, TXT (text file containing data in the alphanumeric form), CSV (text file in which the values are separated by a comma) and DBF (database file). The data import is possible after ensuring compatibility with the desired data source specification. In addition, for some modules it is possible to import data from an external database. Another feature is to export the data. According to the assumptions all generated reports are displayed on the screen first and only on-demand printed or saved to one of the supported formats.

An important issue is security and access control. The system automatically verifies the substantive correctness of the input data. It is acceptable to input incomplete data and complete them later. Access control in the system is implemented in two ways: first by giving to users appropriate permissions of access to system modules and functions and second by control their powers to modify (e.g. set time limits, in respect of which the older documents are not modified) [12].

### 5. Structure of data collection

The database system consists of two independent and accessible under other websites databases: statistical and surveyed. The first of them is used to collect statistical data at the national level, and the second to collect inventory and measurement data, coming directly from farms. Easy and transparent use of the system is possible due to basic modules and several smaller databases. The basic modules of the system are:

- *Objects* (type: building, field, storage),
- *Livestock population*,
- *Crops*,
- *Manure storage*,
- *Readings*,
- *Gases emissions*,
- *Odors emission*,
- *Parameters*,
- *Reports*.

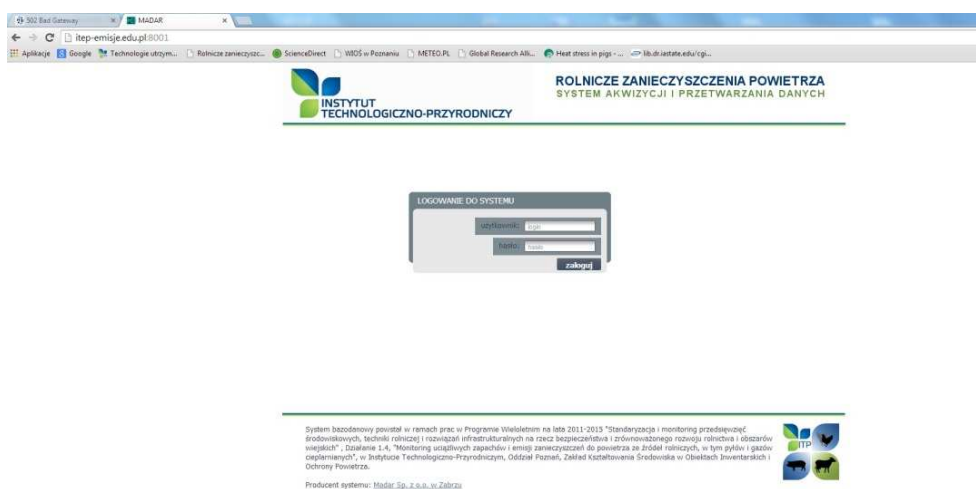


Fig. 1. Login screen

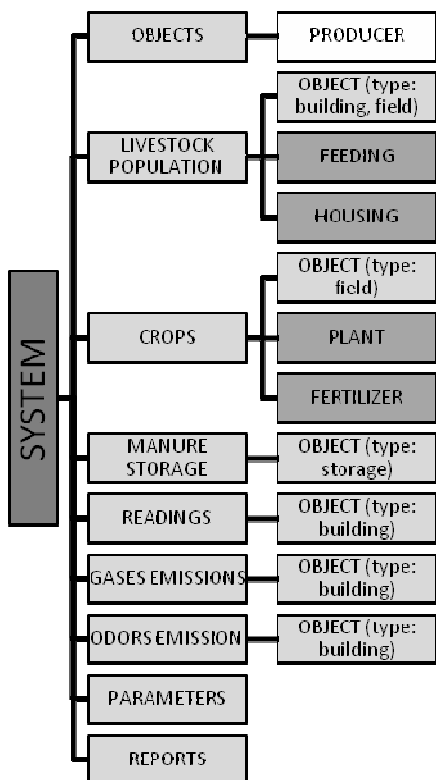
Rys. 1. Ekran logowania do systemu

Source: own work / Źródło: opracowanie własne

The additional databases are:

- *Producer*,
- *Plant*,
- *Fertilizer*,
- *Feeding*,
- *Housing*.

All modules and additional databases in system are connected to each other (Fig. 2).



Source: own work / Źródło: opracowanie własne

Fig. 2. Diagram of connections between modules and additional databases  
Rys. 2. Schemat powiązań modułów i dodatkowych baz danych w programie

Modules *Objects*, *Livestock population* and *Crops* are used to input both, the statistical data (statistical database) and inventory data (surveyed database). Additional modules: *Manure storage*, *Readings*, *Gases emissions* and *Odors emission* are available in surveyed database and used

to enter measurement data from farms. The module *Parameters* contains constants or rarely changes indicators and factors which are necessary to the calculation of emissions (Fig. 3). Their values are derived from the literature on air pollution emissions from agricultural sources.

The above listed modules and additional databases of system operate in a hierarchical structure, which systematizes and facilitates the entering and recording data.

Modeling of agricultural production based on separate components. The primary component is the *Object*.

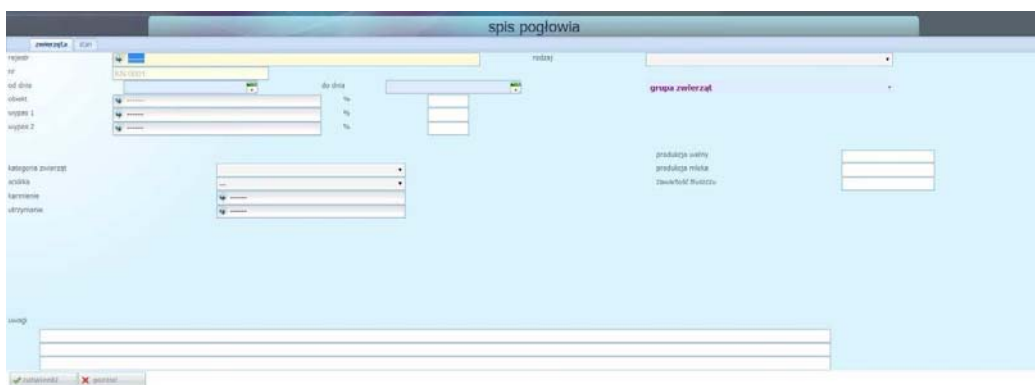
There are three types of *Object*: building (livestock buildings), field (crop fields, pastures) and storage (manure storage). Each *Object* is connected to a definite agricultural producer. Furthermore, each *Object* has got own location according to the territorial division of Poland. It should be noted that due to the protection of personal data, detailed information on agricultural producers are stored individually and are not available to external users.



Source: own work / Źródło: opracowanie własne

Fig. 3. Start screen  
Rys. 3. Ekran startowy

*Object* type building is attributed by the *livestock population* which is a time-varying parameter. That is why each change is marked with a specific moment of time. To enter data about number of animals, housing and feeding systems, etc. is used *Livestock population* module together with additional data bases *Feeding* and *Housing* (Fig. 4).



Source: own work / Źródło: opracowanie własne

Fig. 4. Data input form in *Livestock population* module  
Rys. 4. Formularz wprowadzania danych w module *Pogłowie*

Poglowie okresowo  
okres 01/01/2011 - 31/12/2011

jednostka emisji kg

lp	rodzaj	ilość tys. szt.	obsada	EN2OMan	EFAM	EN2OGMan	EN2OLMan	EN2OGR
1	Lochy	409	409	151575	79696, 6	19924, 1	22414, 7	0
2	Lochy z prosiętami	716	716	636072	334843	83710, 6	94174, 5	0
3	prosięta 20-30kg	3557	3557	568115	299154	74788, 5	84137	0
4	warchlaki 30-70kg	3585	3585	1233360	665212	166303	187091	0
5	Tuczniaki 70-110kg	4789	4789	1647770	888619	222155	249924	0
6	Kury nioski	49909	49909	536577	239677	59919, 3	67409, 2	0
7	Brojlery	90055	90055	741539	296615	74153, 9	83423, 1	0
8	Indyki	8175	8175	235347	94138, 6	23534, 7	26476, 5	0
9	Kaczki	2644	2644	33903, 6	13561, 5	3390, 36	3814, 16	0
10	Gęsi	1430	1430	20089, 5	8035, 78	2008, 95	2260, 06	0
11	krowy mleczne 4-6 Mg mleka	2568	2568	5580100	2518860	699743	787211	700288
12	Cieleta 0-12 mies	1362	1362	417868	173403	49825, 9	56054, 1	64751, 7
13	Młode bydło 12-24 mies	1256	1256	1065660	458188	128686	144772	141391
14	Pozostałe bydło 2 lata i więcej	315	315	366756	161439	45243	50898, 4	48833, 7
15	Jagnię < 1 roku	48	48	4669, 97	1867, 99	574, 7660	646, 6110	1077, 69
16	Owce > 1 roku	165	165	31653, 6	12661, 4	3956, 7	4451, 29	7913, 4
17	Kozy	112	112	18319, 7	7327, 89	2358, 4	2653, 2	5264, 29
18	konie	254	254	172498	68999	22128, 5	24894, 5	48787, 2
	razem	171. 349, 00	171. 349, 00	13. 461. 861, 6	6. 322. 297, 02	1. 682. 404, 96	1. 892. 705, 56	1. 018. 307, 06

Source: own work / Źródło: opracowanie własne

Fig. 5. An example of generated report

Rys. 5. Przykład raportu generowanego w bazie

## 6. Calculation methods

The main function of the system is the calculation of gases (CH<sub>4</sub>, N<sub>2</sub>O, NH<sub>3</sub>), particulate matter (PM<sub>2.5</sub> and PM<sub>10</sub>) and odors emissions from agricultural production. Gas and particulate matter emissions are calculated on the basis of available, international and self-developed methodologies, while the odor emissions based only on self-developed methodology.

The system uses the methodology of the Intergovernmental Panel on Climate Change and the European Monitoring and Evaluation Programme [1, 4, 5, 10]. Greenhouse gases, ammonia and particulate matter emissions are calculated on the basis on the parameters and emission factors included in the methodology instructions. These are the standard values that have been determined for Western European countries and do not necessarily describe the specificity of agricultural production in Poland. Therefore, where it was possible self-developed methodology was used, national parameters and emission factors. This will allow determining own emission factors of greenhouse gas, ammonia, particulate matter and odors, that take into account the characteristics of Polish agriculture and describe its specificity. The classification of agricultural air pollutants emission sources used in system is consistent with international methodologies.

## 7. Data presentation

An important element of the database system is to present the processed results in the form of reports what is possible with the use of *Reports* module. User has got the ability to define the boundary conditions that are included when data are downloaded from the system. The aggregation and grouping data are possible according to the needs and expectations of users. Data are presented as – tables, diagrams or summaries (Fig. 5).

## 8. Summary

The database system "Agricultural Air Pollution. Acquisition and Data Processing System" allows the collection of statistical, inventory and measurement data, which are used for the calculation of the gases, particulate matter and odors

emission from agricultural sources. Based on the collected data it will be possible to determine own specific emission factors of greenhouse gases, ammonia, particulate matter and odor for Poland. In the future, the system may provide an extensive database and be useful to verify the cyclic reports of greenhouse gases, ammonia and particulate matter emission from agriculture. This knowledge may be helpful under developing national strategies for this sector.

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