

Research of the utilization of biotechnological agents for the reduction of ammonia and greenhouse gases emissions in livestock breeding in the Czech Republic

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Abstract: The reduction of ammonia and greenhouse gases emissions resulting from the livestock breeding is conditioned by the performance of many experiments for the reducing technologies verification. The utilisation of biotechnological agents in the livestock breeding enables to reduce not only ammonia but in many cases also the principal greenhouse gases. In the paper is presented the system and methodology of the measurements, the choice of more than eighty authorised measurements, and the determination of the emission factors for methane, carbon dioxide, hydrogen sulphide, and nitrogen oxide from pig and poultry breeding.

Keywords: ammonia; greenhouse gases; BAT; BREF; biotechnological agents; livestock breeding

The problems of the reduction of ammonia and greenhouse gases emissions resulting from agricultural activity have become an instrument of administrative organs for the solution of the relations of agriculture to environment. Currently that issue is highly topical not only in the Czech Republic and Slovakia but also in the framework of EU.

The requirements of Gothenburg and Kyoto protocols have committed individual countries to relative significant reductions of ammonia and greenhouse gases till 2012. In the Czech Republic this represents the ammonia emissions reduction to a value smaller than 80 kt of emissions emitted annually to 2010 of which 95% come from agricultural activity. As the greenhouse gases regards, it represents in total the reduction by 8% to 2012. That value seems to be low but it consequently means considerable methane (CH₄), carbon dioxide (CO₂), hydrogen sulphide (H₂S), and nitrogen oxide (N₂O) reduction. Agriculture produces in particular methane and nitrogen oxide.

The Research Institute of Agricultural Engineering, has been dealing with the problems of the reduction of ammonia and greenhouse gases emissions for three research periods, i.e. for 12 years in total. Gradually, a methodology was worked-up for measuring in the stable environment, slurry and

farmyard manure landfills and for the placement of these organic residuals into soil.

Biotechnological agents have currently become an integral part of the breeding technology for many breeders in the Czech Republic. By the application of the Act on air protection No. 86/2002 and the Act on integrated prevention and pollution control No. 76/2000, the breeders have to maintain strict emission limits and to prove the application of the so called best available techniques (BAT) when asking for the integrated permission of farming.

The BAT techniques are based mainly on the relations to the air protection, i.e. the reduction of ammonia and other burden gases emissions. The referential document BREF determines particular BATs for pig and poultry breeding and is a result of the international working group activity governed from Seville (Spain) and comprising all EU Member States. In the BREF are named the verified technologies applicable in all the EU Member States. A contribution of the Czech Republic consists of the application of the verified biotechnological agents which are relatively cheap from the view of the user (breeder) and easily applicable without the need of the consequent investment. This technology is currently considered the national BAT.

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The problems of technological agents for ammonia emissions have been presented by foreign and Czech authors since 1990 when the measuring procedures were improved and allowed to carry out long-time measurements in stables and residual biomass landfills. For ammonia emissions, the frequently mentioned was De-Odorase (AMON *et al.* 1995) or *Yucca schidigera* (KEMME *et al.* 1993).

With the development of biotechnologies and the interest for the emissions reduction, the contributions regarding other biotechnological agents were published, e.g. Amalgerol (GJORDSLEV 1992), Biopolyme FZT (HÖRNIG & BRUNSCH 1999). HOLUB *et al.* (2000) presented the verification of the agent Biostrang 510 in chicken broilers fattening. Also NÁVAROVÁ (2001) presented the results of Amalgerol utilisation in the chicken broilers breeding.

Currently, the Czech market offers about 35 tested biotechnological agents.

METHODOLOGY AND MATERIALS

Authorised measuring of NH_3 , CH_4 , CO_2 , H_2S , and N_2O concentrations resulting from agricultural activity is carried out by the gas analyser INNOVA 1312 using infra – red opt acoustic, completed with the measuring points switcher INNOVA 1309. The measured values are calculated by the apparatus to normal state conditions and stored continually and automatically. Air temperature as well as relative humidity are measured continually and recorded by the registration device COMMETER L3120. The air pressure values are continually measured and recorded by the device COMMETER D4141. The air-conditioning parameters are measured by the anemometer TESTO 445. During or after the measurements the following quantities are computed from the measured values. Mass concentrations of NH_3 , CH_4 , CO_2 , H_2S (%), air flow rate (m^3/s), pollution substance specific flow (m^3/s), specific production emission ($\text{kg}/\text{animal}/\text{year}$) or emission factor of the measured emission ($\text{kg}/\text{animal}/\text{year}$).

Prior to the beginning of each authorised emissions measurement, the local verification is conducted of the measuring device by means of calibration gas. The ammonia and greenhouse gases emissions measuring is carried out continually for at least 24 hours to provide objective monitoring of the emissions generating process in all daily regimes (silent phase, animals active phase, feeding time etc). The probes withdrawing air samples are situated in the measured object vents (in the front of the withdrawal fans) of cattle, pigs, and poultry breeding. The measurements and determinations of the

ventilation parameters are provided in accordance with the standard ČSN 12 4070 (1999) (equivalent ST SEV 5882-87).

After the measuring, the data found are evaluated. The evaluation is performed in the following steps:

- Conversion of volume concentration to mass concentration of pollutant for related conditions when humidity, temperature, and static pressure of waste gas are in compliance with the operational parameters.
- Determination of ventilated air quantity by calculation from measured values of flowing speed and airflow section.
- Determination of hourly amounts of emissions produced and consequent conversion of that value to emission factor (or to specific production emission).
- Determination of measurement uncertainty (according to documents of European cooperation for accreditation EA 4/02) and presentation of measured and calculated values in tabular form.

The measuring is performed in two identical halls (stables) with equal numbers of animals of the same or similar age. In one hall, the tested agent is applied according to its nature to feeding, drinking, litter, floor or under – grate space, in the other hall a classical feeding and drinking is applied without any agent. In both halls the ventilation is set-up at equal constant air flow-rate for the whole measuring time. The measuring is carried out for at least 24 hours and within one day, if possible. The calculation of the emissions reduction follows after the evaluation of both measurements from the difference of the specific production emission.

Biotechnological agents utilised

Agents on principle of adsorption. These are agents containing a selected sorbent as a principal effective matter binding odour substances or other harmful gaseous catabolites of organic matter decomposition.

Agents utilising specific ability to bind chemically certain emitted gaseous (liquid) compounds. These are agents, currently obsolete, which in mutual interactions inactivate the main investigated gaseous burden factor (mostly ammonia) by chemical destruction. These agents are instantaneously usable, their effectiveness occurs gradually, mainly by the degree of their solubility, blending perfection with the treated substrate and its topical physical-chemical properties.

Agents utilising enzymatic activities. Enzymes are mostly complicated protein structures,

equipped with the ability of catalytic regulation and usually also direct and indirect stimulation of biochemical processes and decomposition of the waste materials organic structures, i.e. gaseous, liquid, and solid.

Biological agents

(a) Substances containing lyophilic strains of selected biodegradation micro organisms: in fact, they occur in the form of cans of mono – or even polycultures adapted in terms of their long-time conservation through lyophilisation, and completed in addition with some starting activators and initiatory substances. Before their utilisation, the process of revitalisation is necessary to provide to fully functional vegetative forms of the originally lyophilised microbial matter with different lengths of life from some hours up to some days or weeks.

(b) Substances supplying adapted live cultures of decomposition strains: they represent an analogy to the previous group but with considerably limited durability and storage ability and with huge volume parameters.

(c) Agents providing positive microbial decomposition via multiplication and growth of natural microbial strains present in the treated environment: agents on the basis of selected natural materials (see algae extracts, vegetable oils, ether components, and

some trace bio stimulators) for systematic stimulation of growth and multiplication of the positive natural microbial community complex from native population of the treated environment.

The measuring was carried out in the facilities of pigs and poultry breeding. For particular reasons, the name is not presented of the biotechnological agent in order to avoid legal problems.

The authorised measurements of ammonia emissions in livestock breeding were completed by simultaneous measuring of the greenhouse gases emissions – CH₄, CO₂, H₂S, or N₂O. These measurements served not only for the determination of the basic emission values of the investigated greenhouse gases for particular categories of animals, but also for finding if the verified biotechnological agent influences the reduction or increase of the emissions monitored.

RESULTS OF MEASUREMENT

By 2006, more than 80 authorised measurements of ammonia and greenhouse gases emissions had been carried out. For the purpose of this article, we have made the selection of these measurements and presented them in the tabular and graphical forms. All these measurements were used for the basic determination of the greenhouse gases emissions factors.

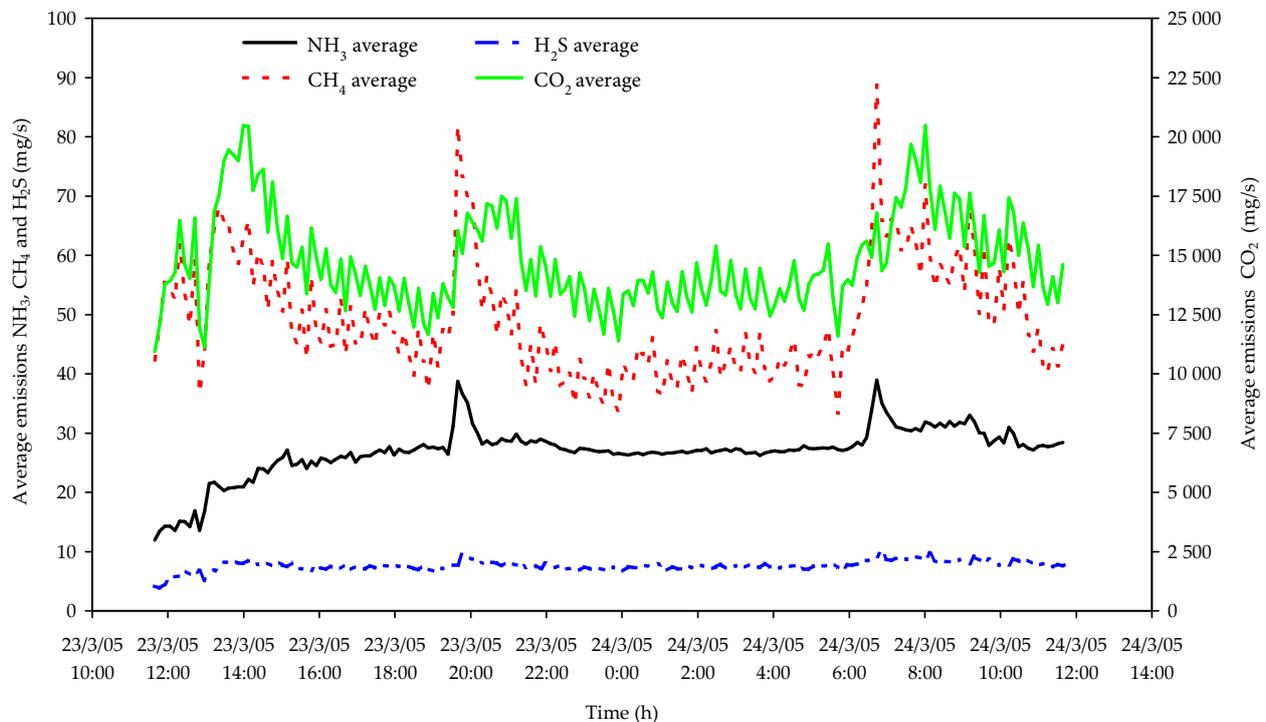


Figure 1. Average emissions of measured gases – fattening pigs farm Stepanovice, hall 3 control stable

Table 1. Specific production of ammonia and greenhouse gases emissions in control stables and in those with biotechnological agent application for category fattening pigs

No.	Housing	Specific emission production (kg/animal/year)									
		CO ₂ (C)	CO ₂ (A)	CH ₄ (C)	CH ₄ (A)	H ₂ S (C)	H ₂ S (A)	N ₂ O (C)	N ₂ O (A)	NH ₃ (C)	NH ₃ (A)
002/04	partially grate floor, concrete laying*	1467.17	947.81	6.27	5.06	1.40	0.93	n.m.	n.m.	3.740	3.076
001/05	partially grate floor, concrete laying	2563.04	1292.59	8.55	3.33	1.32	0.82	n.m.	n.m.	4.66	3.323
009/05	partially grate plastic floor, elevated concrete laying	1957.10	1053.13	13.84	8.26	1.64	1.22	n.m.	n.m.	3.24	2.297
010/05	partially grate plastic floor, concrete laying	2087.19	2140.50	7.39	10.73	1.38	1.57	n.m.	n.m.	5.57	3.861
012/05	partially grate plastic floor, concrete laying	1410.62	1019.79	6.15	4.32	1.80	1.34	n.m.	n.m.	3.73	2.973
021/05	partially grate plastic floor, concrete laying	939.88	837.46	2.42	2.24	0.96	0.82	n.m.	n.m.	2.50	2.054
026/05	concrete floor with deep litter	2453.23	2076.10	7.40	6.71	1.45	1.33	n.m.	n.m.	5.71	5.053
007/06	partially grate floor, concentrate laying	1600.73	1792.91	1.10	3.40	n.m.	n.m.	0.15	0.39	4.37	4.175
024/06	partially grate floor, concentrate laying	897.62	1035.96	4.01	4.80	n.m.	n.m.	0.18	0.24	3.57	3.479
026/06	partially grate floor, concentrate laying	1040.84	1078.97	4.58	4.55	n.m.	n.m.	0.23	0.22	3.31	3.177

*In this measuring the results from the hall with BTA application were compared with the emissions values of Table 3 (C) – control stables; (A) – stables with the agent application; n.m. – not measured

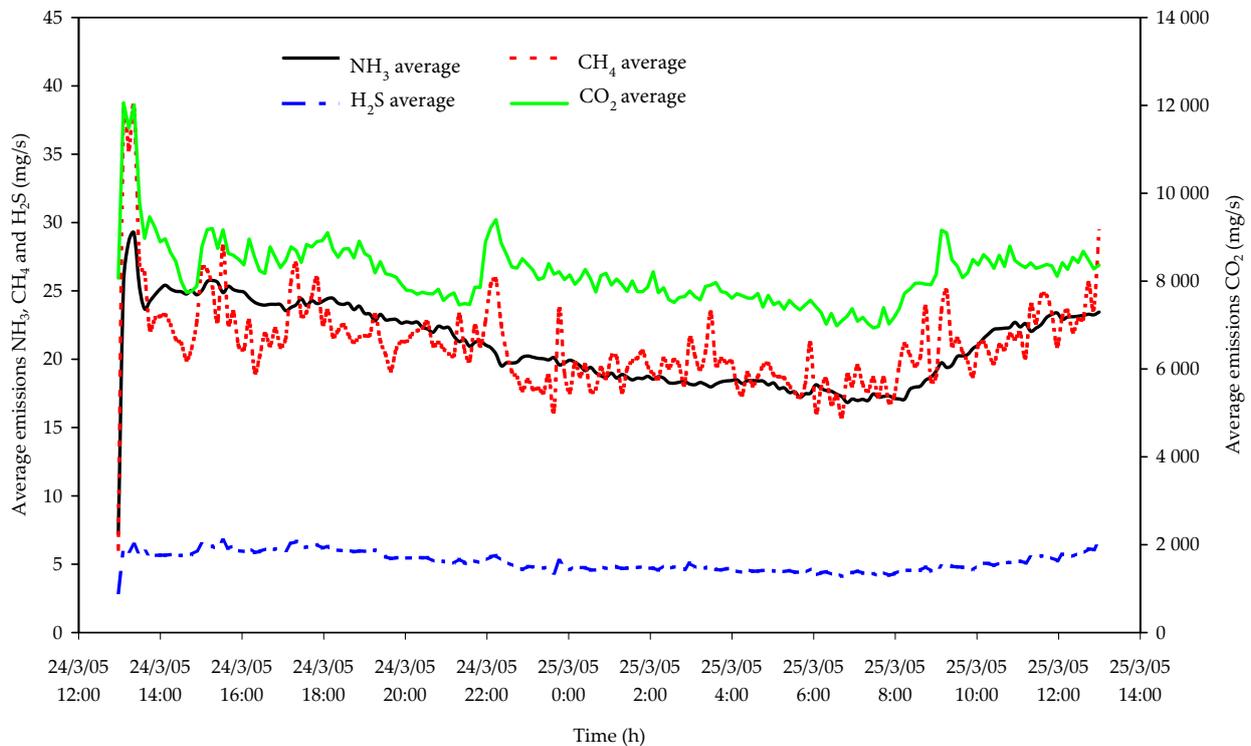


Figure 2. Average emissions of measured gases – fattening pigs farm Stepanovice, hall 5 agent applied

Fattening pigs

The selection of 10 measurements has shown how the emissions of particular gases are reduced or increased. Measurements 002/04, 001/05, 009/05, 012/05, 021/05, 026/05 have proved that the biotechnological agents used significantly reduce ammonia and also the monitored greenhouse gases (Table 1).

Agent 010/05 significantly reduces ammonia emissions, but on the other hand the greenhouse gases emissions are higher. Agents in the measurements 007/06, 024/06, 026/06 measured in 2006 have shown that with relatively slight reduction of ammonia emissions an increase occurs of the monitored greenhouse gases emissions. In Figures 1 and 2 are indicated the courses of the converted average emissions of the monitored gases from one selected measurement.

Chicken broilers breeding

For comparison, we have chosen the measurements performed with straw litter (Table 2). Eight from 15 biotechnological agents measured reduce

ammonia and greenhouse gases emissions. In other measurements, the greenhouse gases increase occurs simultaneously with a relatively considerable ammonia emissions reduction. In Figures 3 and 4, the courses are indicated of the converted average emissions of the monitored gases from one chosen measurement.

In Table 3, specific production emissions for ammonia and the monitored greenhouse gases so far determined are presented for livestock categories – pigs and poultry. The comparison of the theoretically determined values (present value) and the experimentally found value proves that the experimentally found values are higher. It is caused by the fact that the theoretically determined values are specified by the matter balance and do not respect technological differences of breeding. Although the difference between the theoretically determined and really found values is not significant, this fact should be taken into account. With all experimentally found values, Figures 5 and 6 have been generated for the pig and poultry breeding which indicate how the possible emissions reduction of the monitored gases can be reached using biotechnological agents.

Table 2. Specific production of ammonia and greenhouse gases emissions in control stables and in those with biotechnological agent application for the category chicken broilers

No.	Housing	Specific emission production (kg/animal/year)									
		CO ₂ (C)	CO ₂ (A)	CH ₄ (C)	CH ₄ (A)	H ₂ S (C)	H ₂ S (A)	N ₂ O (C)	N ₂ O (A)	NH ₃ (C)	NH ₃ (A)
009/04		66.30	47.19	0.08	0.09	0.03	0.03	n.m.	n.m.	0.17	0.14
003/05*		61.39	69.31	0.35	0.07	0.02	0.03	n.m.	n.m.	0.13	0.07
004/05		87.42	50.94	4.71	0.93	0.02	0.01	n.m.	n.m.	0.06	0.03
007/05		46.75	34.61	0.06	0.05	0.02	0.01	n.m.	n.m.	0.03	0.02
023/05	straw litter on whole surface	46.01	47.14	0.07	0.06	0.04	0.03	n.m.	n.m.	0.09	0.09
027/05		116.63	91.80	0.08	0.07	0.03	0.03	n.m.	n.m.	0.29	0.23
030/05		66.71	42.69	0.09	0.05	0.02	0.01	n.m.	n.m.	0.04	0.02
035/05		36.67	37.70	0.05	0.02	0.01	0.02	n.m.	n.m.	0.12	0.07
037/05		38.05	24.25	0.03	0.01	0.01	0.01	n.m.	n.m.	0.18	0.11
017/06		57.13	55.71	0.14	0.20	n.m.	n.m.	0.002	0.003	0.07	0.04
016/06		57.13	55.42	0.14	0.20	n.m.	n.m.	0.002	0.003	0.07	0.04
023/06		62.37	57.58	0.14	0.13	n.m.	n.m.	0.023	0.017	0.11	0.08
029/06		98.30	83.32	0.39	0.35	n.m.	n.m.	0.020	0.022	0.25	0.24
031/06		64.20	62.81	0.16	0.14		n.m.	0.015	0.015	0.24	0.18
034/06	77.96	51.12	0.20	0.11	n.m.	n.m.	0.024	0.011	0.23	0.12	

*In this measurement the results from the hall with BTA application were compared with the values of Table 3 (C) – control stables; (A) – stables with the agent application; n.m. – not measured

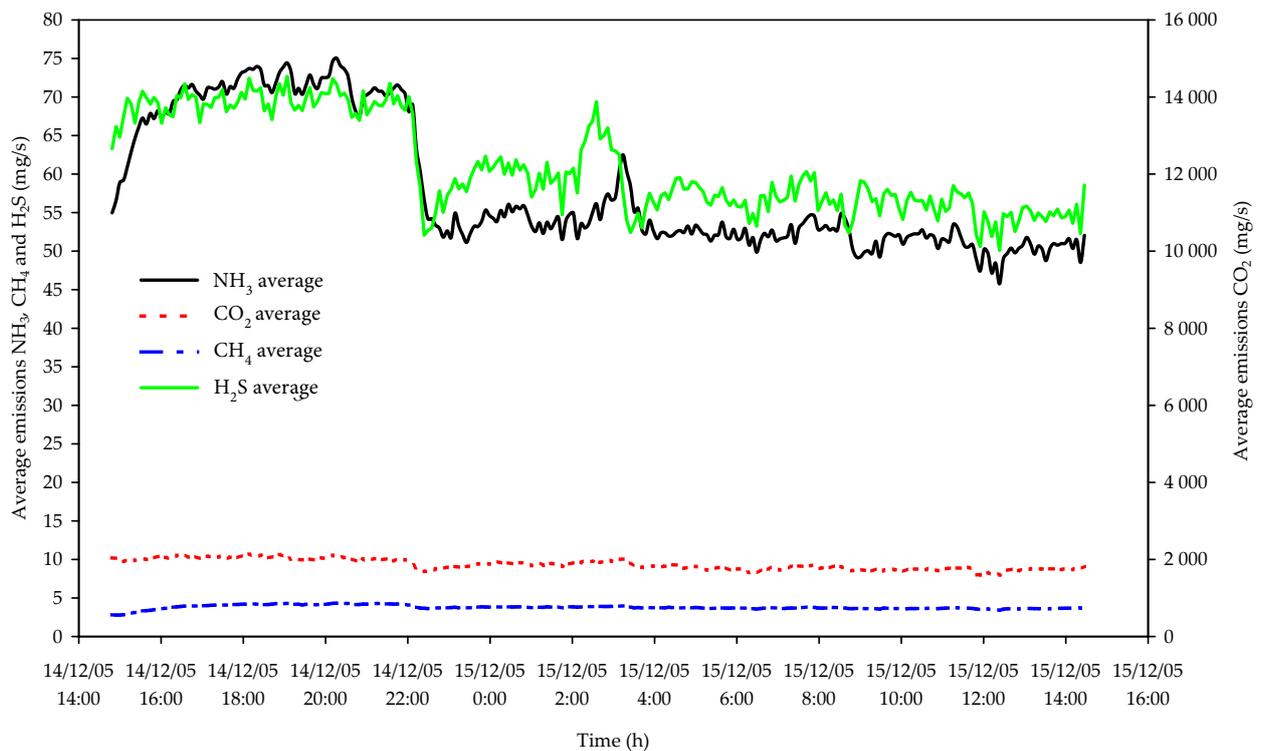


Figure 3. Average emissions of measured gases – chicken broilers fattening farm Bezdekov, hall 2 control stable

CONCLUSIONS

The performed research of the biotechnological agents utilisation for the reduction of ammonia and greenhouse gases emission creates a basis for the

generation and introduction of new BAT technique from the view of air and environment protection including breeding animal welfare. The extensive research has confirmed the hypothesis – namely, that a suitable composition of the biotechnological

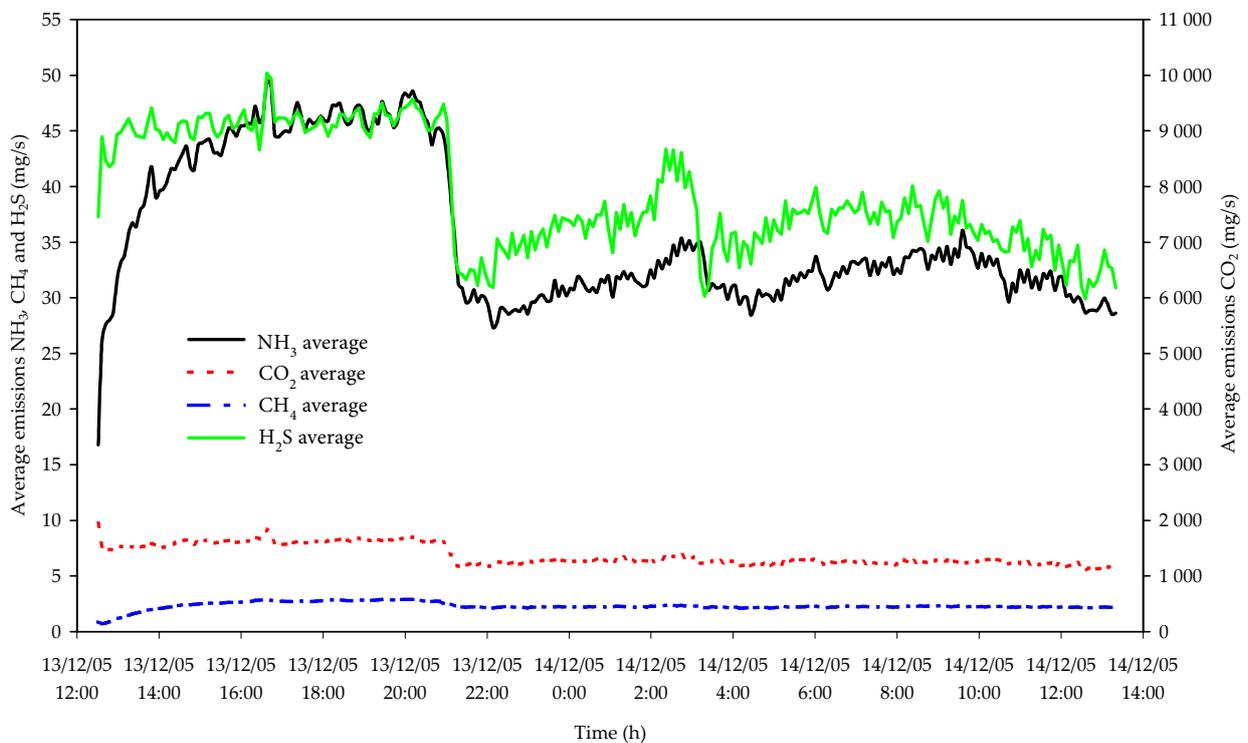


Figure 4. Average emissions of measured gases – chicken broilers fattening farm Bezdekov, hall 1 agent applied

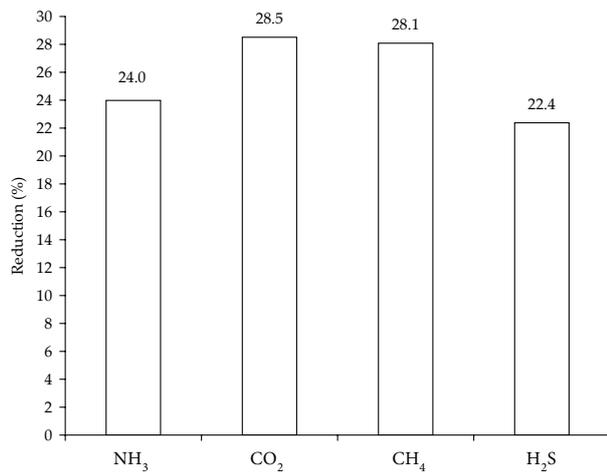


Figure 5. Average reduction of greenhouse gases and ammonia emissions in fattening pigs breeding

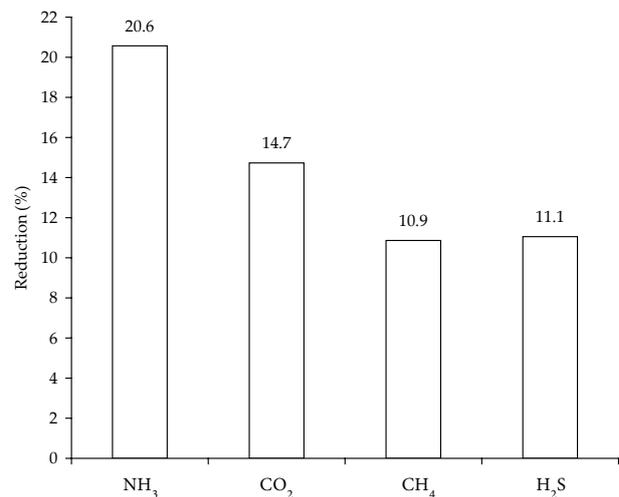


Figure 6. Average reduction of greenhouse gases and ammonia emissions in the chicken broilers breeding

Table 3. Comparison of the specific production emissions found for greenhouse gases and ammonia with so far used emissions

Animal category	Specific emission production (kg/animal/year), for category „suckling sow“ (kg/kg/year)									
	present value					experimentally found value				
	CH ₄	CO ₂	H ₂ S	N ₂ O	NH ₃	CH ₄	CO ₂	H ₂ S	N ₂ O	NH ₃
Cattle total										
Dairy cows	67.00				10.00					
Bulls	34.64				6.00					
Heifers	22.00				6.00					
Calves	18.40				6.00					
Pigs total										
Sow	3.80				7.60					
Pregnant		not specified				5.56	2690.62	2.27		7.22
Suckling		not specified				0.04	18.54		0.003	0.06
Pigs fattening	4.33				3.20	6.27	1467.17	1.40	0.24	3.74
Piglets and gilts	2.75				2.00	1.78	1062.57	0.49		1.91
Poultry total										
Laying hens	0.07				0.12	0.11	64.33	0.03	0.02	0.18
Broilers	0.07				0.10	0.35	61.39	0.02	0.02	0.13
Turkeys	0.07				0.35					
Ducks	0.07				0.35					
Geese	0.07				0.35					
Horses	47.20				6.00					
Sheep total	5.77				0.62					
Dairy sheep		not specified								
Other		not specified								
Goats total	4.13				0.62					
Dairy goats		not specified								
Other		not specified								
Rabbits		not specified			0.84					

agent will allow the reduction not only of ammonia but also of the greenhouse gases emissions. Elimination of such agents, which do not comply with that hypothesis or are suitable only for certain gases is a basis for establishing agents complex officially recognised as reducing. The Czech Republic has been appreciated for the activity in the presentation of these results and there exists the presumption that the described technology will be classified as BAT.

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Abstrakt

JELÍNEK A., DĚDINA M., KRAUS R. (2007): **Výzkum využití biotechnologických přípravků pro snížení emisí amoniaku a skleníkových plynů v chovech hospodářských zvířat v České republice.** *Res. Agr. Eng.*, **53**: 126–133.

Snížování emisí amoniaku a skleníkových plynů z chovů hospodářských zvířat je podmíněno provedením řady experimentů při ověřování snižujících technologií. Využití biotechnologických přípravků v chovech hospodářských zvířat umožňuje snížení nejen amoniaku, ale v mnoha případech i hlavních skleníkových plynů. Je uveden systém a metodika měření, výběr z více než osmdesáti autorizovaných měření, sestavení emisních faktorů pro metan, oxid uhličitý, sirovodík a oxid dusný z chovů prasat a drůbeže.

Klíčová slova: amoniak; skleníkové plyny; BAT-technika; BREF; biotechnologické přípravky; chovy hospodářských zvířat

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