Research of biological agents effects on reduction of ammonia concentration in stables of intensive farm animals breeding

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ABSTRACT: In the study are presented results of experiments using bio-technological agents Amalgerol, Bio-Algeen G-40 and BIOSTRONG 510 in intensive pig, poultry breeding and cattle slurry treatment for ammonia emissions reduction. The measuring was conducted, suggested and verified by continual method through the measuring station ASECO and instrument 1312 Photo-acoustic Multi-gas Monitor of firm INNOVA Air Tech Instruments. The reached results confirm unambiguously possibility to reduce ammonia emissions from farm animals breeding.

Keywords: ammonia emissions; living environment; slurry; pigs; poultry

The living environment distress is connected currently not only with industrial production but also agriculture is the biggest producer of toxic gas – ammonia (NH_3). Emissions of that gas originate mainly in the farm animals breeding and generate within storage and handling with farmyard manure, slurry, poultry excrements and litter. Agriculture influences considerably landscape. Agricultural activity in landscape has impact on basic elements – land, water and atmosphere.

Therefore it was necessary in compliance with effort for long time sustainable development to accept many measures considerably reducing unfavourable affects of agriculture activity on environment. In European Union was elaborated system of directives making a basis of ecological understanding for agricultural technologies operations. In the Czech Republic were accepted some acts and directives fully in compliance with EU legislation which considerably would effect agriculture in a future.

From aspect of ammonia emissions and their leakage from livestock stables the key legislation are Act No. 86/2002 on atmosphere protection and Act No. 76/2002 on integrated pollution prevention and control (IPPC). These acts significantly change the view on emissions of load gases as ammonia (NH_3), methane CH_4, carbon dioxide CO_2, nitrogen oxides NO_x, hydrogen sulphide H_2S and other, e.g. odour gases. The Acts No. 76/2002 and 86/2002 specify categories of farm animals under their competence.

The act on integrated pollution prevention and control defines the best available techniques (BAT):

– "best" – the most effective technique from point of view of high level of environment protection as a whole;
– "available" – technique enabling its introduction under economically and technically acceptable conditions;
– "technique" – used mechanisation, technology or method how the system is suggested, built, maintained, operated and excluded from activity.

In the Czech Republic is verified the possibility to use the bio-technological agents for ammonia emission reduction from agricultural activity in framework of the National Agency for Agricultural Research projects based on enzymatic substances, bio-alginates, bacteria etc. and to suggest that technology as BAT. Verified were agents containing extracts from crop YUCA, sea algea, agents based on phytogenous additives, mixtures of vegetable oils etc. The agents were verified within experiments realised for individual categories of farm animals in stable environment and excrements storage and their application on soil.

MATERIAL AND METHODS

Measuring instruments and methods of continual measuring of load gases emissions

At present is required by the Government Decree No. 353/2002 to the Act on atmosphere protection a continual measuring using apparatus for continual measuring at least within 24 hours. In the EU are being used electrochemical sensors or photo-acoustic spectroscopy as measuring methods.

For ammonia emission measuring in stables and slurry storage the following instruments will be used:

1312 Photo-acoustic Multi-gas Monitor, INNOVA Air Tech Instruments, Denmark, No. 028-002; year of production 2002

This study was worked-up on basis of the Project National Agency for Agricultural Research QD0008 solution – *Research of Technologies for Pigs and Poultry Breeding, Reducing Ammonia Emissions Affecting the Living Environment*.

1309 Multipoint Sampler, INNOVA Air Tech Instruments, Denmark, No. 177-002; year of production 2002

D3121 Thermometer and air hydrometer with data record, Comet system, Ltd. No. 0910039; year of production 2001

L3120 Thermometer and air hydrometer with data record, Comet system, Ltd. No. 01070176; year of production 1999

D4141 Thermometer, air hydrometer and manometer with data record, Comet system, Ltd. No. 03910485; year of production 2003

TESTO 445 Air-flow speed meter with exchangeable probes, TESTO, Ltd. Germany, No. 00463417/011; year of production 2001

The measuring instruments comply with requirements of standard ČSN EN ISO/IEC 17025. The instruments measuring deviation:

1312 Photo-acoustic Multi-gas Monitor_of INNOVA Air Tech Instruments. -NH_3 ± 0.2 mg/m^3; CO_2 ± 3.4 mg/m^3;

COMMETER 03121, temperature ± 0.21°C; humidity ± 1.8%.

Method with utilisation of photo-acoustic spectroscopy (FAS)

For measuring of ammonia concentration will be used the device 1312 Photo-acoustic Multi-gas Monitor of firm INNOVA Air Tech Instruments with multi-channel sampling and portioning system 1309.

The principle of measurement is based on absorption of infrared light passing through the sample of gas. The photo-acoustic method measures directly the amount of absorbed light energy by measuring the acoustic energy radiated by the gas molecule before this has absorbed the light. The measured signal evaluation is conducted by means of appropriate software, processed and recorded. The apparatus enables to measure simultaneously in one site up to 5 gases and water vapour.

At the end of 2003 this method was approved by the Czech Inspection for Environment and by Ministry of Environment of the Czech Republic for authorised measuring of ammonia emissions.

The withdrawing sites layout

The withdrawing site layout has a significant effect on objectivity of measured values. In prevailing amount of new or modernised stables for pigs and poultry breeding is used the forced ventilation. For measuring of ammonia concentration with respect to environment loading we choose the withdrawing site as close as possible to the output fans or slots in dependence on type of ventilation (negative pressure or positive pressure), where ammonia concentration in stable is highest, but not just in the flow of the drawn off air.

For measuring and analysis of quantities is necessary to distribute measuring to some sites.

The withdrawal sites in stable are placed:

In zone of animals, i.e. in part of stable reserved between floor and height of staying animal or cage ceiling;

In zone of operators, i. e. in part of stable determined for motion of operators providing basic maintenance of technology, poultry, treatment, veterinary control etc. Measuring is conducted in the respiration zone of standing man.

In zone of ventilation, i.e. in space where ammonia emissions leave into atmosphere. Mostly it concerns measuring on drawing off ventilators. Measuring is significant for determination and verification of emission factor in framework of emission amount announcement into integrated register of pollution.

METHOD OF MEASURED RESULTS EVALUATION AND CALCULATION RELATIONS

Calculation of pollutant concentration

For calculations are used relating conditions, when humidity, temperature and static pressure of load gas correspond to typical operational parameters.

Conversion is done by the relation

$$\rho\,(ZL) = \varphi\,(ZL)\,.\,M\cdot(ZL)\cdot\frac{p}{RT} \qquad \text{(mg/m}^3\text{)} \qquad (1)$$

where: $\rho\,(ZL)$ – mass concentration of pollutant (ZL) in waste gas at temperature T and pressure,

p (mg/m^3) – (note: 1 mg = 10^{-3} g),

$\varphi\,(ZL)$ – volume friction of pollutant in waste gas (ml/m^3),

$M\,(ZL)$ – molar mass of pollutant (g/mol),

P – static pressure of waste gas (Pa),

R – gas constant (8.314 J/mol.K),

T – thermal-dynamic temperature of waste gas (K).

Specification of waste gas volume flow

The flow speed is specified by anemometer. Average volume flow of waste gas

$$\overline{q}_i = v_i S_i\, 3{,}600 \qquad \text{(m}^3\text{/h)} \qquad (2)$$

where: v_i – average speed of flow (m/s),

S_i – surface of measuring section (m^2).

Total average volume flow of waste gas

$$q_v = \sum_{i=1}^{n} q_i \qquad \text{(m}^3\text{/h)} \qquad (3)$$

Calculation of pollutant mass flow and emission factor

Average mass flow $\overline{q}_m\,(ZL)$ of individual pollutants is specified alternatively in dependence on relating conditions from relation:

$$\overline{q}_m\,(ZL) = \overline{\rho}\,(ZL)\,.\,\overline{q}_v \qquad \text{(mg/h)} \qquad (4)$$

Calculation of emission factor for given category and age of farm animals, excrements landfill and handling with excrements.

Emissions factor

$$EF = \frac{\bar{q}_m\,(ZL).\ 8.76.10^{-3}}{n_i} \quad \text{(kg/animal place/year)} \quad (5)$$

where: n_i – number of animals producing load substance (ZL) (–),
– $8.76.10^{-3}$ constant expressing conversion of relation to kg/animal place/year (–).

METHOD OF EVALUATION

The measured values evaluation is conducted as follows:

1. Conversion of volume concentration to mass concentration of pollutant according to relation (1) for relating conditions, when humidity, temperature and static pressure of waste gas correspond with typical operational parameters.
2. Determination of ventilated air amount by calculation of measured values of air flow speed and its section according to relationship (2).
3. Determination of produced emissions amount per 1 hour according to relationship (4).
4. Conversion of determined values to emission factor (or specific production emission).
5. Determination of measuring uncertainty (according to documents CIA European co-operation for EA 4/02 accreditation).
6. Summarised presentation of measured and calculated values in tabular form. In case of necessity the results completion by significant information connected with measuring and resulting values of determined quantities.

Functional characteristics of bio-technological agents

The **Amalgerol** agents are composition of selected native substances with known supporting character for general biological processes. The basic structure is created by effective mixture of specific vegetable oils (sunflower, rape and soy in food quality) bound together with purposefully selected vegetable extracts, particularly those from selected sea algae, harvested from natural rejuvenated cultures, occurring in rich and clear coastal water of Island. Their polyuronic structures together with selected etheric oils and vegetable oil substance are a base of selective stimulated abilities of Amalgerol. These are in addition completed by component of paraffin distillates of pharmaceutical qualitative class. The microelement surfaces in any of described agents are safely under the hygienic limit level. The Amalgerol Classic and Premium were approved for practical utilisation in the Czech Republic by decision of Control Checking and Testing Institute for Agriculture Prague, the Amalgerol Stall Max FL agent was approved more over by the Institute for State Control of Veterinary Bioagents and Medicaments.

Amalgerol Classic (slurry treatment on co-operative farm Krásná Hora – cattle breeding)

This agent stimulates development of microbial strains participating in biodegradable processes and simultaneously consumes products of this decomposition for cellular tissues of own strain within process of rapid multiplication. The process is described by many authors (NOVÁK et al. 2003; VOSTOUPAL et al. 2003). This is a schematic explanation of principle of micro-biotechnological conservation of nitrate parts from decayed matters, conserved in such form inside the substratum, resistant against uncontrolled decomposition except the gaseous fractions. This causes significant limitation of current emissions – up to by 40–68%. By verification in practice was confirmed (NÁVAROVÁ 2001) its declared activity and effectiveness by utilisation in our country and abroad – e.g. in Austria, Denmark, Sweden, for dairy cows, saws, pig fattening, calves and hens (GJORDSLEV 1992; JELÍNEK et al. 2001a; SCHERNER 1993). But even at the farms operations optimisation – multifunctional for profit in animal and consequently also crop production within the only application program input as informed by our and Austrian farmers.

This agent is able to decompose the cellulose structure of crust on cattle slurry surface and to liquidate it sufficiently by excited microbial activity. It is also able to crush sediments in the pig slurry containers and to provide possibility of their evacuation from storage containers.

The experiences acquired and published by farmers in Denmark (GJORDSLEV 1992, 1993) where besides generally presented emissions reduction from the stables they also found out increased feed conversion for heifers and sows and in addition also improvement of conception after 1st insemination.

Significant and in the main substantiality bearing effect is the ammonia emission reduction as well as some so called greenhouse gases from the animal production (but also from other bio-technologies producing odour catabolits). Currently was repeatedly verified in sufficient wide extent (HUTTERER 1992; JELÍNEK et al. 2001a,b; NOVÁK et al. 2003) its important effect on odour decayed gases production reduction generating spontaneously from the excrement matter, i. e. slurry and other classical farmyard manure including so called litter etc. Further also for cleaning and desodoration of stable and appropriate drainage systems and sump space for excrements.

In some European countries and also in the Czech Republic was proved its strongly favourable effect on digestive tract microflora normalisation of mainly polygastric animals (poultry and ruminants) after its peroral application in form of individual portioning (GJORDSLEV 1992, 1993; SCHERNER 1993). This effect resulted not only in significant improvement of digestive processes but also in minimal gases generation in the digestive tract of housed animals and this by limitation of continual production of methane and non-methane load of environment by animal production.

The Bio-Algeen agents are based on hydrolysat of brown sea algae *Ascophyllum nodosum*.

For pigs and poultry serves the Bio-Algeen Biopolym containing humin acids, vitamin and trace elements and gluco-oligosacharides represent optimal living environment for lactobacteries (bacillus sustilis, entrerococcus faecium etc) and bifidobacteries. The Bio-Algeen labelled FZT, FZ Liquid or FZ Granulate is adopted as supplement for feeding or drinking water. It acts favourably on development of stomach and intestinal microflora, makes digestion more effective in the small intestine and accelerates nutrition transfer into blood circulation. All these aspects influence better nutrition condition of organism.

Similarly like for other agents also for pigs is evident the fattening period shortening, higher yield, ammonia emissions reduction by 40–50%, better natality of born piglets, removal of diarrhoca deceases etc. Its application in poultry keeping the eggs production has increased, as well as shell strength and better yoke colour was reached. For broiler was reached higher daily weight increment, feed and drinking water consumption decrease and lower kill. For pigs the ammonia emissions were reduced by about 40–50% with consequent energy consumption reduction for stable ventilation.

The Bio-Algeen G-40 (ammonia emissions reduction in pig breeding on farm in Nevid) contains amino-acids, short chain peptides, organic acids, minerals, uronic acids, anxines and vitamins. It acts as significant activation factor supporting development of autochthonous and saprophytic slurry microflora. It means that the Bio-Algeen in solution with water represents together with the animals' excrements a living medium for intensive micro-organism development. This causes acceleration of natural, biological degradation of excrements with simultaneous odour reduction. These properties are used particularly for single decomposition of old sediments in under – grid space and storage reservoirs. To improve the stable microclimate and prevention of sediments creation in slurry farming the agent is regularly applied in small portions. The treated slurry is homogenised, stabilised and cleaning with favourable effect on animals, operators and living environment and during about 5 days is ready for soil fertilisation. The slurry is almost without odour due to reduction of nitrates in form of ammonia consumed on microclimate development and thus is bound in their proteins.

In stables and sow fattening plants of firm Guazamara – Cuevas de Almanzora (Almeira-Spain) was found out reduction by 60% of ammonia emissions for piglets after application of granulate Biopolym FZ. Thus these are able to feel better the aromatic matter of additional feeds through their highly developed scent what increases amount of accepted feed. The ammonia content reduction by 60% for fattening pigs in stable significantly reduced occurrence of respiration decreases (SCHULZE, HERMSEN GmbH 2002).

In experiment conducted in Germany in the fattening halls with chicken broilers by using of agent Biopolym FZT, applied into drinking water was found out average ammonia emissions reduction by 40% (HÖRNIG et al. 1999a).

The experiment carried out also in Germany in stables for chicken broilers fattening on deep litter by company Storkower, Ltd. in 1998 and 1999 by using of agent Biopolym FZT brought result of ammonia emissions reduction in average by 45% and 49% (HÖRNIG et al. 1999b) what confirmed the result reached in Holland (GROOT KOERKAMP, METZ 1998) where was also measured the ammonia emission reduction by 45%.

Utilisation of Biopolym Granulate for pigs fattening conducted on farm Dubravica – Croatia (TOFANT et al. 1999) with 420 pigs housed on partially grated floor in pens for 10 pigs brought in average 65% reduction of ammonia emissions and 50% reduction of pig mortality was found out in consequence of respiration deceases.

Similar agents stimulate positive microbial decomposition by multiplication and growth of natural microbial strain activity, present in the treated environment. There exist agents on basis of selected natural materials (sea algae extracts, vegetable oils, etheric components and some trace bio-stimulators) for systematic encouraging of growth and multiplication of positive natural microbial community complex from the native fitting of the treated environment. Their effectiveness is different and often depends on method of their application. Generally, these agents increase the slurry and treated litter fertilisation effects.

For pigs are suitable the agents AROMEX ME PLUS and ENVIRO PLUS, based on combination of selected crop and etheric oils mixture absorbed on mineral carrier SiO_2. Etheric oils act as protective compound against mould, bacteria and some virus. The tri-terpenoid saponines improve permeability of tissue systems and thus also nutrition absorption – phosphorus and nitrogen. The saponines also take part in reduction of ammonia generation by enzyme ureases activity inhibition.

For poultry are determined agents BIOSTRONG 510 and also ENVIRO PLUS based on combination of selected crop and etheric oils absorbed on mineral carrier SiO_2. The essential oils stimulate production of saliva and stomach juice during feed reception and improve feed conversion and daily weight increments. In broiler feeding was found out by the Mendel University of Agriculture and Forestry Brno about 52% of ammonia emissions reduction (KLECKER 2000) what was confirmed also on co-operative farm Mašovice, farm Lukov where emission reduction by 50% was achieved (HOLUB et al. 2000). On farm Obříství of Agroservis Zlomice company was found out reduction of ammonia emissions up to by 78% in a half of the fattening cycle (TOLÁREK et al. 1997). For turkeys fattening in Drahobudice the ammonia reduction was by about 30% (TOLÁREK et al. 1999). So far as trials in abroad are concerned there was found by about 45% less nitrogen and by about 10% less nitragene in poultry excrements after the agent ENVIRO PLUS application in Szöd (Hungary) and in Schwerin (Germany) respectively. There also was found out a by about 1–2% decreased mortality of fattened chicken broilers.

RESULTS

Verification of bio-technological agents Amalgerol Classic for ammonia emissions from cattle slurry on farm Krásná Hora

The purpose of measuring was determination of ammonia emissions amount generating during cattle slurry storage and finding selected reference quantities (environment temperature, relative air humidity). The results are utilised for determination of applied agent Amalgerol effect on NH_3 generation suppression.

The measuring was conducted in three reservoirs far cattle slurry on farm Krásná Hora. The dairy cow housing is loose on concrete floor with automated slurry removal in roofed halls.

Slurry is stored in two covered collecting reservoirs and two open lagoons. Capacity of individual reservoirs with topical level of filling is presented in Table 1.

Table 1. Capacity and topical level of measured reservoir filling

Reservoir	Capacity (m^3)	Topical level of filling (m^3)
Reservoir No. 1	96	32.00
Reservoir No. 2	97	24.25
Reservoir No. 1	3,500	1,273.00

In reservoirs No. 1 and 2 slurry was held without agent application for emissions reduction. In lagoon No. 1 the agent Amalgerol was applied according to supplier instructions.

The measuring uncertainty is determined according to documents of Czech Accreditation Institute European co-operation for EA4/02 accreditation.

Measuring No. 1 – reservoirs

The measuring device was installed on 14. 5. 2003 at 1:00 p.m.

The probes for ammonia concentration measuring were within all time of measuring period placed in measuring chamber in the ventilated gas flow. Concentrations measured by individual sensors were continually recorded. The sensors for temperature and relative humidity measuring were placed adjacent the outdoor probe in distance 3 m from the reservoirs opening.

Reading-out and storage of measured values began on 14. 5. 2003 at 1:0 p.m. Interval of values storage from individual sensors was adjusted for 7 minutes. The device operated until 15. 5. 2003 at 8:45 a.m. For technical reasons (moisture condensation in the intake hoses) it was necessary to interrupt the measuring between 9:0 p. m. To 7:0 a.m. Total time of measuring No. 1 was 9 hours 15 minutes. Within the measuring no problems has occurred. In Fig. 1 is shown the distribution of scanning probes in the reservoirs.

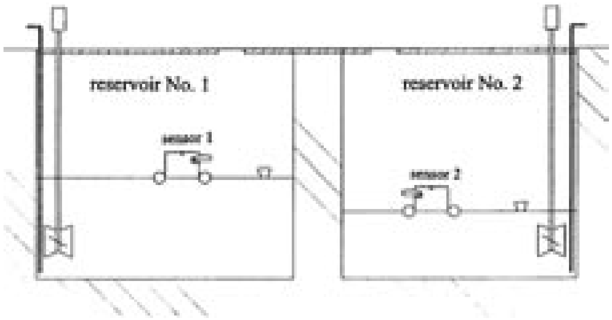

Fig. 1. Disposition of scanning probes in reservoirs

Measuring No. 2 – lagoon

The measuring device was installed on 15. 5. 2003 at 7:35 p.m.

The probes for ammonia concentration measuring were placed in the measuring chamber in the flow of ventilated gases within all time of measuring period. Concentrations measured by individual probes were continually recorded. The sensors for temperature and relative humidity measuring were placed adjacent the probe No. 4 inside the lagoon in distance 3 m from the lagoon margin. In the held slurry was applied the agent Amalgerol according to supplier instructions.

Reading – out and storage of measured values began on 15. 5. 2003 at 10:00 a.m. The interval of the value storage from individual sensors was adjusted for 7 minutes. The device was in operation continually until 15. 5. 2003, 7:30 p.m. Total time of measuring was 9 hours 30 minutes. Within the measuring no problems occurred. In Fig. 2 is shown distribution of scanning probes in the lagoon.

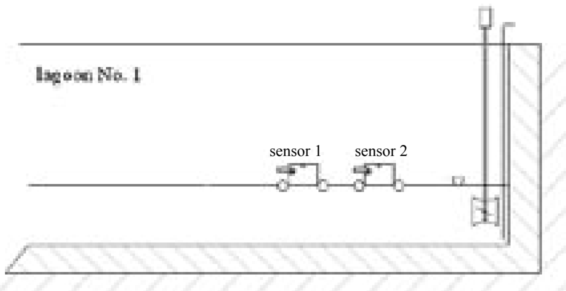

Fig. 2. Disposition of scanning probes in lagoon

RESULTS OF MEASURING

Measuring No. 1 – reservoirs Nos. 1 and 2

In Figs. 3–5 is graphically shown course of temperature, relative air humidity and NH_3 concentration above slurry surface and surroundings during measuring No. 1.

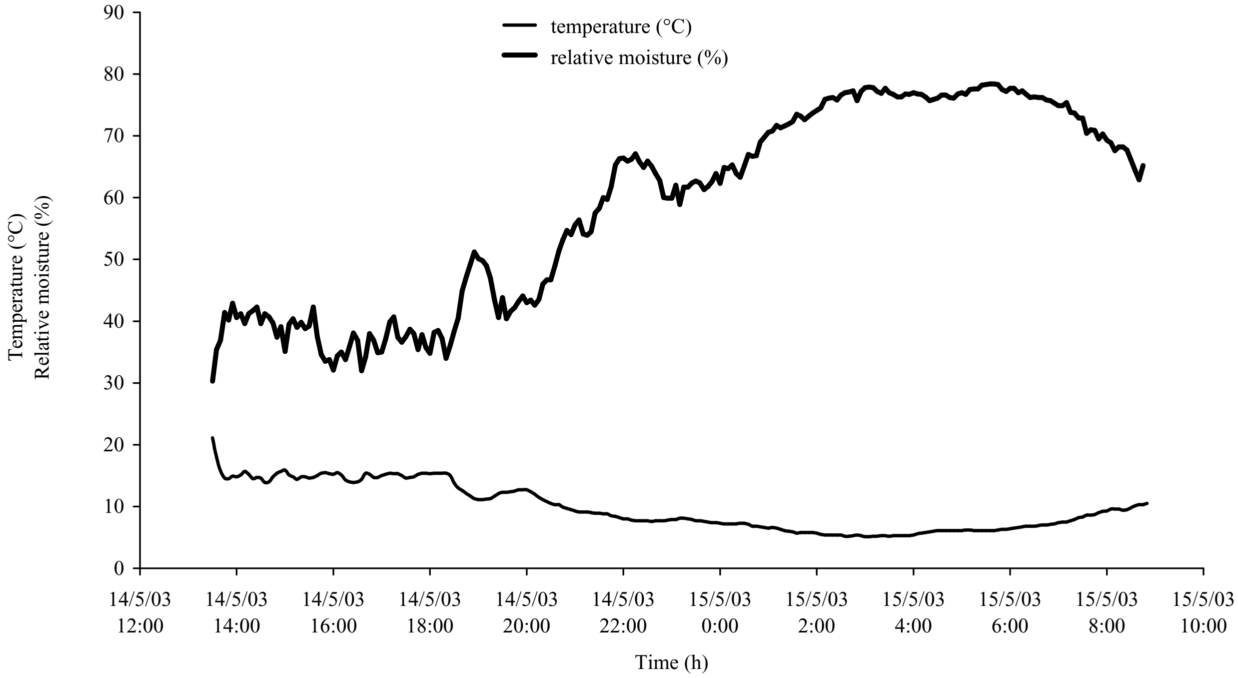

Fig. 3. Course of relative moisture and outdoor air temperature during measuring of reservoirs 1 and 2. Farm Krásná Hora on Vltava on 14. 5. 2003. Untreated slurry in reservoirs Nos. 1 and 2

The standard deviation of relative humidity measuring was ± 16.01% and was calculated into correction of NH_3 concentration.

Measuring No. 2 – lagoon

In Figs. 6–7 is graphically shown course of temperature, relative humidity and NH_3 concentration above treated slurry during measuring No. 2 in the lagoon.

The standard deviation of relative humidity measuring was ± 6.42% and was calculated into NH_3 concentration.

In Figs. 3–7 is graphically shown the course of investigated parameters by means of all measured values.

During measuring No. 1 in reservoir (non-treated) was within 9 hours 15 minutes measured average NH_3 concentration in air above the held surface 40.05 mg/m^3. Average speed of flowing atmosphere was 0.2 m/h. Average air temperature in stable during measuring was 9.73°C and average relative humidity was 58.72%.

During measuring No. 2 in lagoon (treated by agent Amalgerol) was during 9 hours 30 minutes measured the average NH_3 concentration in air above held slurry sur-

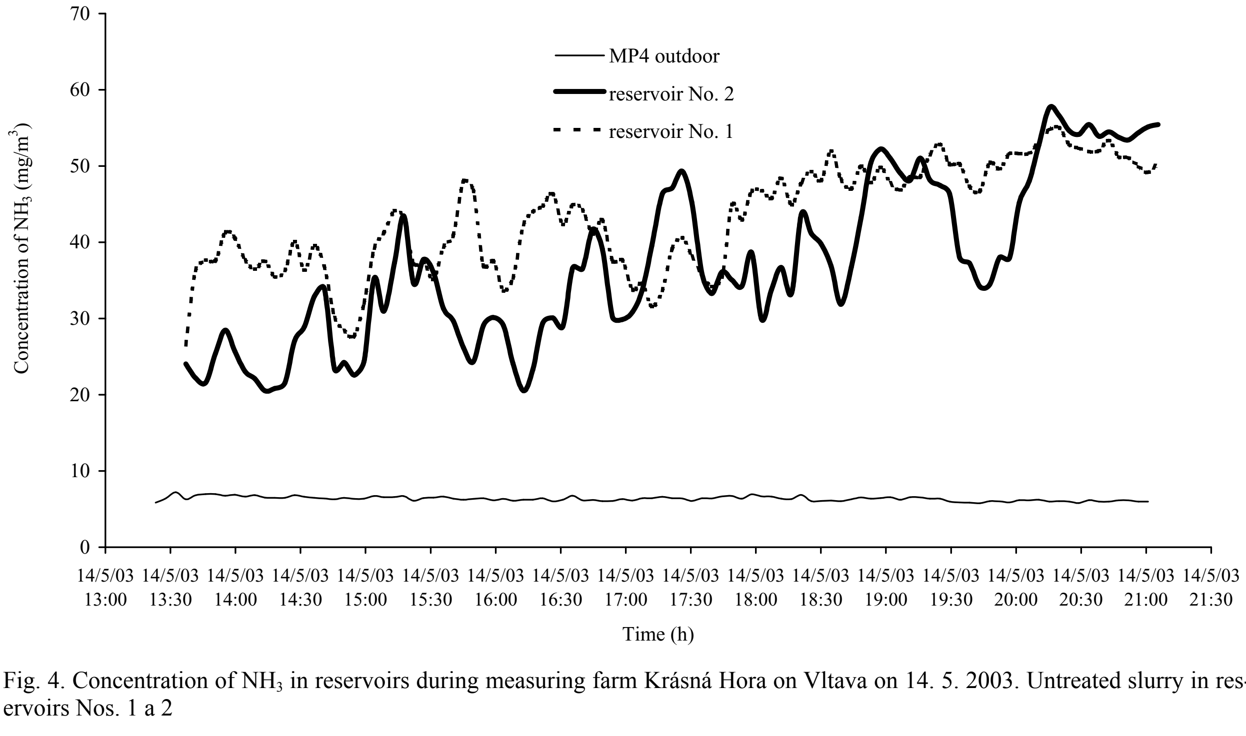

Fig. 4. Concentration of NH_3 in reservoirs during measuring farm Krásná Hora on Vltava on 14. 5. 2003. Untreated slurry in reservoirs Nos. 1 a 2

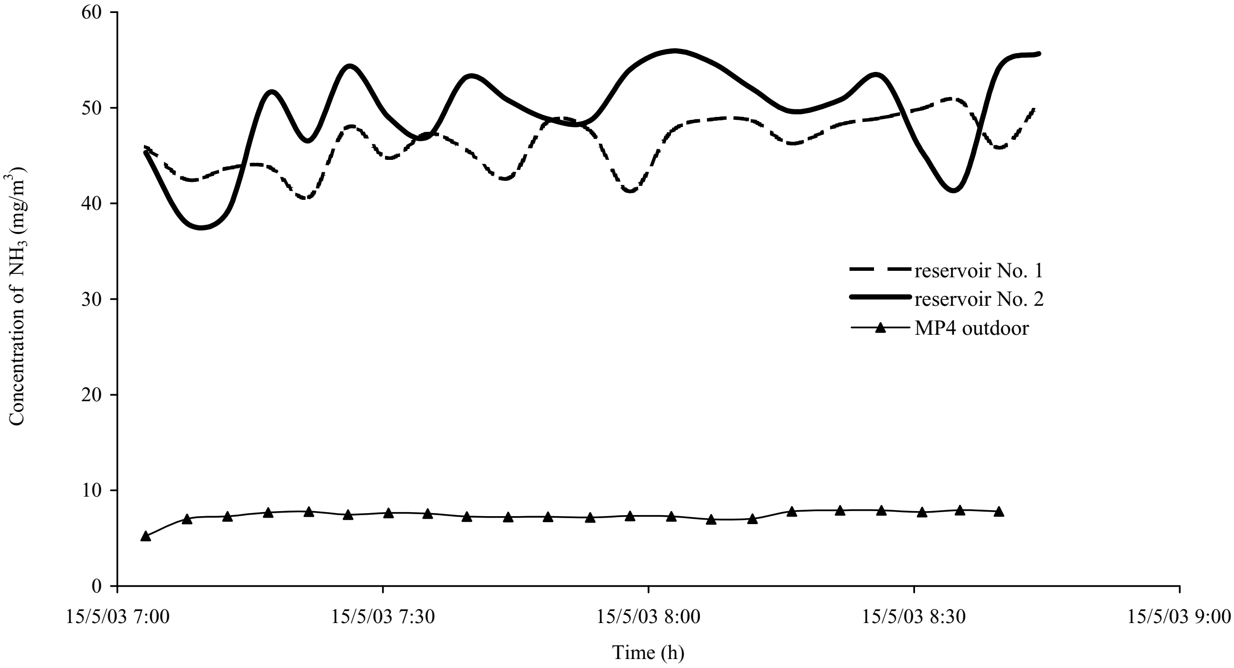

Fig. 5. Concentration of NH_3 in reservoirs during measuring – continuation farm Krásná Hora on Vltava on 15. 5. 2003. Untreated slurry in reservoirs Nos. 1 and 2

face 12.65 mg/m^3. Average speed of flowing atmosphere was 0.2 m/h. Average air temperature in stable during measuring was 11.19°C and average relative humidity 60.54%. The slurry emission factor after treatment by the agent Amalgerol was 0.453 kg NH_3/year/m^3.

From the NH_3 concentration measuring on farm Krásná Hora on 14.–16. 5. 2003 resulted the following conclusion. In the lagoon with stored slurry was recorded the NH_3 concentration 12.65 (2.0532 mg/m^3) above slurry surface with application of the agent Amalgerol. In reservoirs with the stored slurry without application of agent the NH_3 concentration 40.05 (12.620 mg/m^3) was recorded above slurry surface. The treated held slurry produced during the measuring the ammonia amount corresponding with the emission factor 0.453 kg NH_3/year/m^3. The treated slurry measuring in the lagoon displayed the NH_3 emissions reduction 68.41% compared with the non-treated slurry.

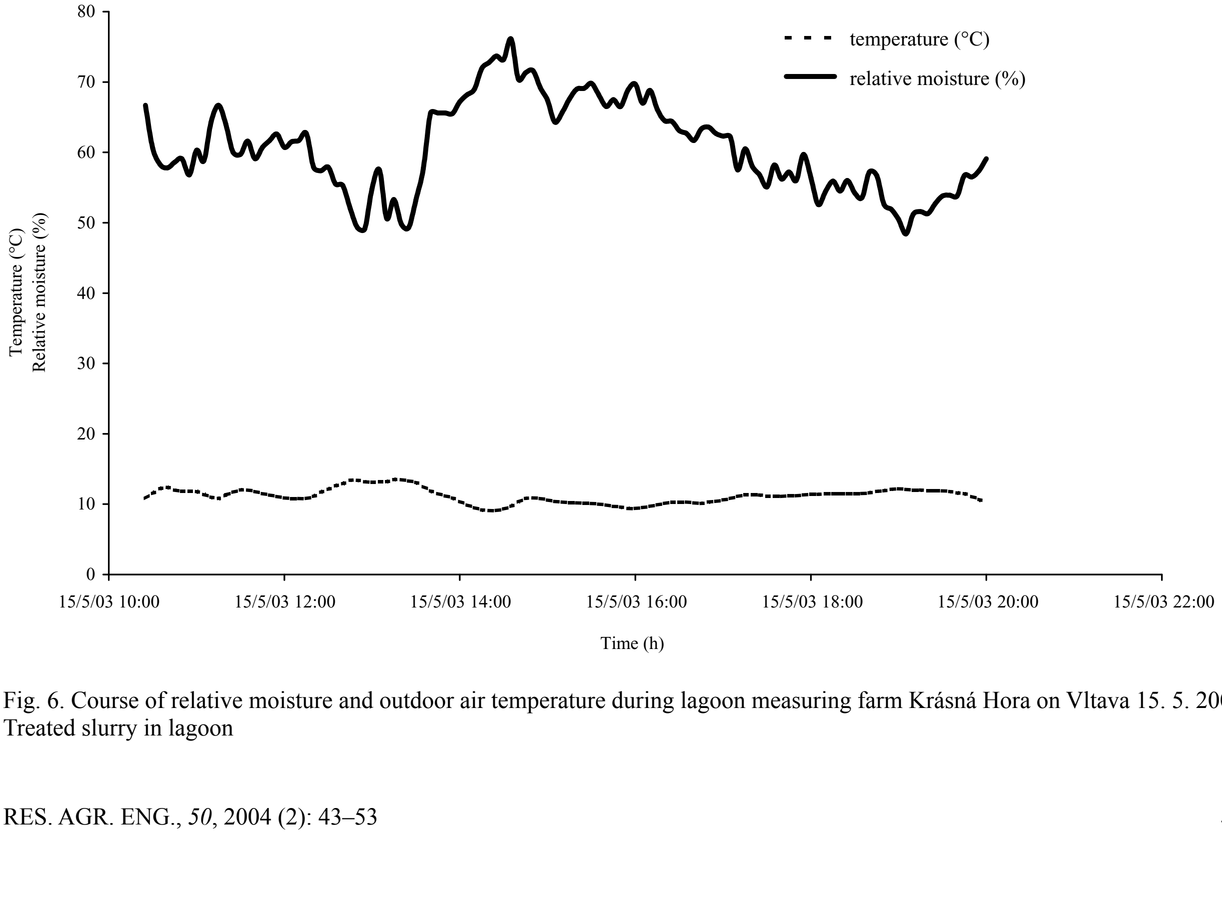

Fig. 6. Course of relative moisture and outdoor air temperature during lagoon measuring farm Krásná Hora on Vltava 15. 5. 2003. Treated slurry in lagoon

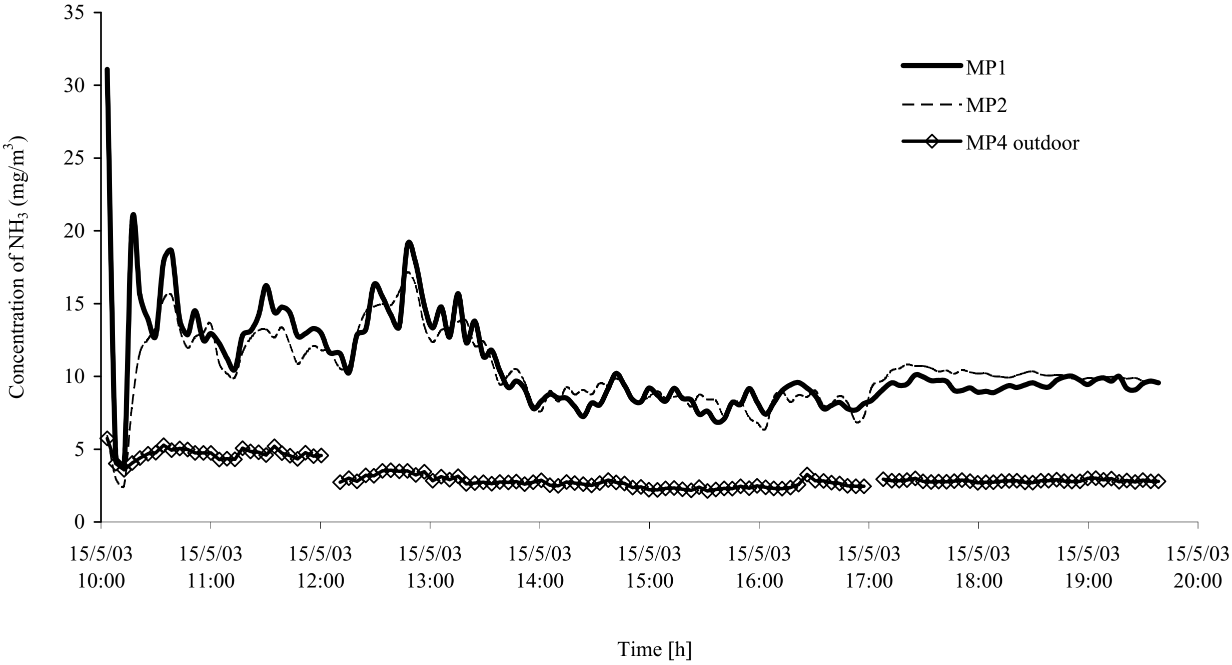

Fig. 7. Concentration of NH_3 in reservoirs during measuring farm Krásná Hora on Vltava on 15. 5. 2003. Treated slurry in lagoon concentration of NH_3

Verification of the bio-technological agent Bio-Algeen G-40 effect on ammonia emissions reduction in pigs fattening on farm Nevid

The purpose of this measuring was determination of ammonia emissions amount generating during pigs breeding and selected referential quantities (environment temperature, relative air humidity). The results are used to specification of the applied agent Bio-Algeen G-40 effect on the NH_3 generation suppression.

The measuring was carried out in two halls on farm Nevid. The pigs are housed in the brick-wall halls. In each hall are 52 pens 4.8 × 2 m with partially slatted floor (slats 2 × 1.1 m) and increased concrete bed. The feed supply is automated with control controlling.

The special layout including installed ventilation is identical in both halls. The ventilation system with active fans is equipped by 6 ceiling drawing off fans and in the side walls are 2 × 27 openings of size 150 × 500 mm with regulation flaps. The air flow from the suction openings is gradually completed by gaseous products of animal metabolism. The animal number housed in the halls during measuring, their age and average weight are given in Table 3.

The agent was applied into wet feed and under-grate channels. During application the supplier instructions have not been adhered to.

The ammonia concentration measuring was conducted according to approved methodology. In the three selected sites in space of the measured facility were placed probes withdrawing air samples (2 probes were placed

Table 2. Measured and calculated values

Measuring	Flow speed (m/h)	Applied agent	Temperature (°C)	Relative air speed (%)	Average concentration of NH_3 (mg/m)	Emission factor NH_3 (kg NH_3/year/m^3)
No. 1 – reservoirs	0.2	untreated	9.73 ± 3.720	58.72 ± 16.100	40.05 ± 12.620	1.44 ± 0.0642
No. 2 – lagoons	0.2	Amalgerol	11.19 ± 1.070	60.5 ± 6.660	12.65 ± 2.053	0.453 ± 0.0735

Table 3. Number of housed fattening pigs in measured halls

Hall No.	Number of animals	Starting data of animals housing	Average animals weight (kg)
2	672	24. 6. 2003	95
3	675	8. 7. 2003	84

by the drawing off ventilators and one in the animal zone). Measuring of the ventilation and ventilation parameters was performed according to the methodology.

In the hall No. 2 was applied the agent Bio-Algeen G-40, hall No. 3 was used for checking without application. During measuring in both halls was adjusted stabile regime of air flowing. By this was provided control of the objectivity of the harmful substance production specification.

The measuring uncertainty is specified by the Czech Accreditation Institute (CAI) European co-operation documents for EA 4/02 accreditation.

The graphical presentation of measuring and its evolution was identical as on farm Krásná Hora. Therefore there are presented only final results involved into Table 4.

In the hall No. 2 (treated) was measured average NH_3 concentration in air in the hall of 8.765 mg/m^3 and CO_2 average concentration in air in the hall of 1,663.938 mg per m^3 within 35.5 hours. Average through flow of ventilation air was 53,730 m^3/h. Average air temperature in stable during the measuring was 19.7°C and average relative humidity was 58.31%.

In the hall No. 3 (non-treated, control) was measured during 35.5 hours average NH_3 concentration in air in hall 9.605 mg/m^3 and CO_2 average concentration in air in the hall 1 was 825.663 mg/m^3. Average throughflow of the ventilation air similarly as in hall 2 was 53,730 m^3/h. Average air temperature in stable was during measuring 19.2°C and average relative humidity 60.4%.

From the NH_3 concentration measuring in two fattening halls on farm Nevid resulted the following conclusions. In identical halls No. 2 and 3 was found out reduction of NH_3 emissions amount at application of agent Bio-Algeen G-40 by 9.1% (emission factor in hall 2 is 6.139 kg NH_3/animal place/year), emission factor in hall No. 3 is 6.698 kg NH_3/animal place/year). This was caused by incorrect application of the agent into wet feeding but also into the under-grid space. Despite this the agent has proved reduction and at correct application the requested emissions reduction would be achieved.

Verification of the bio-technical agent BIOSTRONG 510 effect on farm for chicken broilers fattening in Křepice

The purpose of the measuring was determination of ammonia emissions amount generated during the chicken broilers fattening and assurance of selected referential quantities (environment temperature, air relative humidity). The results are used for determination of the applied agent effect on BIOSTRONG 510 on the NH_3 generation suppression.

The measuring was conducted in three halls on farm Křepice. The chicken broilers housing was on deep straw litter in brick – wall halls of area 2,005 m^2 (hall Nos. 1 and 3) and 527 m^2 (hall 2). The feed supply and drinking are automated with central controlling.

The spatial layout including installed ventilation system in the halls 1 and 3 is identical. The ventilation system with active ventilation is equipped by ceiling and side drawing off fans. Hall No. 2 is equipped only by side drawing off ventilators. The air flow in hall No. 2 was gradually completed by the gaseous products of animal metabolism. Number of animals housed in halls during measuring, their age and average weight are given in Table 5.

The ammonia concentration measuring was carried out according to the methodology. In the three selected sites in space of the measured facility were placed probes withdrawing the air samples. Measuring of the ventilation and ventilation parameters was conducted according to methodology.

In the hall No. 1 the agent BIOSTRONG 510 was applied into the feeding mixture according to the instructions of supplier and halls No. 2 and 3 were used for control without application. During the measuring was always for 1 hour (hall No. 1 and 2: 8–9 p.m., hall No. 3: 5–6 a.m.) adjusted stabile regime of air flowing. By this was provided control of objectivity for harmful substance determination.

The measuring uncertainty is specified according to the CAI European co-operation for EA 4/02 accreditation.

Table 4. Measured and calculated values

Hall No.	Applied agent	Temperature (°C)	Relative air humidity (%)	Average concentration		Average air flow (m^3/h)	Emission factor of NH_3 (kg NH_3/ animal place/year)
				NH_3 (mg/m^3)	CO_2 (mg/m^3)		
2	Bio-Algeen G-40	19.7 ± 3.07	58.3 ± 3.07	8.765 ± 2.0851	1,663.9 ± 1,132.81	53,730	6.139 ± 1.500
3	Control	19.2 ± 3.07	60.4 ± 3.07	9.605 ± 3.0032	1,825.7 ± 943.26	53,730	6.698 ± 2.095

Table 5. Number of housed chicken broilers in measured halls

Hall No.	Number of animals	Starting date of animals housing	Average animals weight (kg)
1	43,965	21. 3. 2003	1.330
2	10,774	19. 3. 2003	1.626
3	43,230	18. 3. 2003	1.650

The graphical presentation of measuring and its evaluation was identical as for farm Krásná Hora. Therefore only final results are presented and processed into Table 6.

During measuring in hall No. 1 (treated was measured during 22 hours) average NH_3 concentration in air in hall 3.019 mg/m^3 and CO_2 average concentration in air in hall 3 232.906 mg/m^3. Average through flow of ventilation air was 70,380 m^3/h. Average stable temperature was 23.7°C and average relative humidity 44.6% during measuring.

During measuring in hall No. 2 (untreated – control 1) was during 22 hours measured average NH_3 concentration in air hall 3.413 mg/m^3 and average CO_2 concentration in air in hall 3 269.649 mg/m^3. Average through flow of ventilation air was 20,573 m^3/h. Average stable temperature was 22.8°C and average relative humidity 44.6% during measuring.

During measuring in hall No. 3 (untreated – control 2) was during 22 hours measured average NH_3 concentration in air hall 3.95 mg/m^3 and average CO_2 concentration in air in hall 2 243.70 mg/m^3. Average through flow of ventilation air was 93,840 m^3/h. Average stable temperature was 22.7°C and average relative humidity 41.7% during measuring. Summarised overview of measured and calculated values is presented in Table 7.

From measuring of NH_3 concentration on farm Křepice resulted the following conclusion. In identical halls No. 1 and 3 was recorded reduced amount of NH_3 emission during application of agent Biostrong 510 by 53.82% (emission factor in hall No. 1 is 0.0423 kg NH_3/animal place/year, emission factor in hall No. 3 is 0.0916 kg NH_3/animal place/year). Measuring in hall No. 2 recorded NH_3 emissions reduction by 25.92% (emission factor 0.0571 kg NH_3/animal place/year).

DISCUSSION

The conducted measurement in 3 different breeding has shown example of bio-technological agent utilisation for ammonia emissions reduction. The lacks of long-time application of Bio-Algeen G-40 agent on farm Nevid have proved a fact, how measuring equipment can reveal poor quality work of operators. By comparison with foreign results it is evident that also this agent materialises conditions for application in Czech animal breeding. The achieved results of Amalgerol and BIOSTRONG 510 are very good as atmosphere protection regards and are fully in compliance with a need of ammonia emission reduction by 40% as requested by EU. Therefore it may be noticed that the suggested method of ammonia emission measuring will enable to verify technology based on bio-technological agents application also from other suppliers and to introduce that technology in the Czech Republic. Application and verification of this technology will be contribution of CR into list of reducing technologies (BAT) within framework of EU.

CONCLUSION

Application and verification of bio-technological agents in livestock breeding will enable to supplier in the Czech Republic to comply with the severe conditions of environmental laws on atmosphere protection and integrated prevention. This technology is characterised by low investment and operational costs as compared with other reducing technologies. The suggested and verified methodology for assessment of bio-technological agent effects was the necessary basis for expansion of that technology. Through its application it

Table. 6. Measured and calculated values

Hall No.	Applied agent	Temperature (°C)	Relative air humidity (%)	Average concentration NH_3 (mg/m^3)	Average concentration CO_2 (mg/m^3)	Air through flow (m^3/h)	NH_3 emission factor (kg NH_3/animal place/year)
1	BIOSTRONG 510	23.7 ± 0.81	44.6 ± 10.54	3.019 ± 1.0741	3,232.9 ± 1,042.99	70,380	0.0423 ± 0.01131
2	Control 1	22.8 ± 1.18	44.6 ± 10.54	3.413 ± 2.0532	3,269.7 ± 651.16	20,573	0.0571 ± 0.00632
3	Control 2	22.7 ± 1.81	41.7 ± 10.65	3.946 ± 1.3124	2,243.7 ± 478.74	93,840	0.0916 ± 0.01846

Table 7. Measured and calculated values

Hall No.	Applied agent	Temperature (°C)	Relative air humidity (%)	Average concentration NH_3 (mg/m^3)	Average concentration CO_2 (mg/m^3)	Air through flow (m^3/h)	Emission factor of NH_3 (kg NH_3/ animal place/year)
1	BIOSTRONG 510	23.7 ± 0.81	44.6 ± 10.54	3.019 ± 1.0741	3,232.9 ± 1,042.99	70,380	0.0423 ± 0.01131
2	Control 1	22.8 ± 1.18	44.6 ± 10.54	3.413 ± 2.0532	3,269.7 ± 651.16	20,573	0.0571 ± 0.00632
3	Control 2	22.7 ± 1.81	41.7 ± 10.65	3.946 ± 1.3124	2,243.7 ± 478.74	93,840	0.0916 ± 0.01846

was possible to verify a lot of agents and to prepare their verified list for suppliers.

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Received for publication March 9, 2004
Accepted after corrections May 31, 2004

Výzkum účinků biotechnologických prostředků na snížení koncentrace amoniaku ve stájích intenzivního chovu hospodářských zvířat

ABSTRAKT: V příspěvku se uvádějí výsledky z experimentů s využitím biotechnologických prostředků Amalgerol, Bio-Algeen G-40 a BIOSTRONG 510 v intenzivních chovech prasat, drůbeže a při ošetření kejdy skotu pro snížení emisí amoniaku. Měření bylo provedeno, navrženo a ověřeno kontinuální metodou měřicí ústřednou ASECO a přístrojem 1312 Photoacoustic Multi-gas Monitor firmy INNOVA Air Tech Instruments. Dosažené výsledky jednoznačně potvrzují možnost snížení emisí amoniaku z chovů hospodářských zvířat.

Klíčová slova: emise amoniaku; životní prostředí; kejda; prasata; drůbež

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