THE UTILIZATION OF WIND-TUNNEL TO ESTIMATE THE DUST CONTENT OF CHOSEN BEDDING MATERIALS

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SUMMARY

The aim of carried searching was to define the dust content of bedding material, as well as new alternative litter supplements, tested in respect of sorption level of toxic gasses, that are commonly used in technology of animals' husbandry on deep litter. Tested was sawdust of conifers, pulverized haloisit (HAL), wheat strowe (WS), pellets feed for chicken (PF) and *Miscanthus sinensis* strowe (sMs). The dusting was performed by using of wind-tunnel, congenial in shape to the Witoszyński-nozzle, what allows obtaining an equal velocity distribution in inlet profile. Such shape of this part has a task to determine the flow velocity in the whole tunnel profile and to eliminate possible turbulences, arising by the inlet. The surface of material tested in the tunnel, as a source of dusting, amounted to 0.09 m^2. In each of tested bedding materials, before performing the test for the level of dust emission, there was defined the water capacity. Tests were performed for 4 velocity ranges of air flow through the tunnel, 0,15, 0,2, 0,3 and 0,5–0,7 m/s. The level of dusting was estimated by using of aspirator AP-2000EX (PN-91-Z-04030/05), being in use to collect samples of air contaminated with industrial dusts from the breathing zone of the laborer on his post, as well as other searching in the flowing range of 0,6 ÷ 2,2 l/min. The collection of air sample from the tunnel was performed by the flowing of 2 l/min.

Each of tested materials has emitted dust by the air movement velocity of 0,3 m/2, except of haloisit, that was dusting already by the air flow velocity of 0,15 m/s. Haloisit also characterized itself with the highest level of dusting.

Keywords: wind-tunnel, dust emission, strowe, haloisyt, pellets feed

INTRODUCTION

Near by such important for animal health adverse admixtures in the air of farm accommodation as ammonia, hydrogen sulphide or number of microorganisms mentioned is also dust. Basically, in the qualification, there are distinguished molecules with diameter to 5 μm, defined as respirabile dust, on the contrary to molecules with diameter over this value – as sedimentative dust [Dobrzyński 1999]. The high level of air dust in livestock rooms acts disadvantageous on the animal health [Dobrzański and Kołacz 1996]. Dust with small diameter penetrates through the mucosa and lungs to the blood flow and can cause arising of pneumoconiosis by the animals. Dust of bigger size settles on the mucosa of upper air passages and conjunctiva, effecting their irritation

and damage. The consequence might be inflammatory state and damaging of natural barrier which mucosa or skin for pathogenic microorganisms are.

Air dust in the rooms for poultry, especially broilers held in the litter system is very high. Wathes at all [1998] have stated medium air dust in broiler room with floor litter system with respiratory dust on the level of 3,6 mg/m^3 and with inhalative dust in amount of 0,45 mg/m^3 and in the summer time the air dust level was 40% higher than in the winter time.

Near by seasonal changes of air dust level in livestock rooms, Hinz and Linke [1998] have noted daily fluctuation. They have determined the level of air dust in the fattening building- during the night on the level to 2 mg/m^3, during the day on middle level from 1 to 5,5 mg/m^3, additionally they have observed sudden rise of air dust during meal of fatteners to the levels containing in the range from 15 even to 25 mg/m^3, what is strictly connected with the activity rise of animals. Usually searching concerning the level of air dust in rooms for poultry and swine, held in litter system, consisted in determination of air dust condition in these structures, depending on litter materials, which were in use and in using of different methods to limit the dusting intensity of litter. Few are reports about *in vitro* tests, with using of wind tunnels to determine the dusting level of different materials being in use as litter for animals or such materials that can be alternative for general used materials. Recognizing of dusting level of the litter material before its application seems to be justified because of the fact that the rise of farm buildings number increases global dust emission to the atmosphere. Report in form of stocktaking of contaminants emission to the atmosphere, worked out by the Institute of Environment Protection, National Centre for Emission Inventory Control, for 2001 [2003] shows estimative, that in Poland dust emission of agricultural descent to the atmosphere, makes 5% of global emission. From this 97,6% (23 524,4 tons) is dust derived from animal production, exactly from processes on the field of animal faeces economy. Robertson at all [2002], have stated during the searching of 4 farm buildings for broilers in Great Britain, among other things in regard of dust emission to the atmosphere, that emission per hour from 1st till 28th or 30th day from settling of the building had risen from the level of 0–5 g/m^3 of dust to 252–505 g/m^3 that confirms the high level of dust emission from big farm structures to the atmosphere.

MATERIAL AND METHODS

In the searching tested were, in regard of dusting, litter materials of general use by poultry farming and breeding (wheat straw – WS, straw *Miscanthus sinensis* -sMS), feed for poultry in granulated form (PF) as well as halloisyte (HAL), used as bedding supplement to limit the emission of injurious gases to the air of livestock house.

The dusting intensity of studied materials was defined for given initial humidity of the material and by fixed air movement speed (0,15; 0,2 0,3 and 0,5 m/s). Every dusting has lasted 15 minutes. Additionally after the ending of the 1st stage there have been performed dustings of these materials in the period of 60 minutes for the air movement speed of 0,6 m/s. Dobrzański [1999] gives, that air dusting in the rooms for poultry shouldn't cross the value from 1 to 3 mg/m^3, depending on the keeping system. Watches [1994] gives, that it can reach the limit to 1,7 mg/m^3 of respiratory non-specific dust.

For the dusting test there was used a wind tunnel. The tunnel is a construction with total length of 5 m and square cross-section. The inlet part of the tunnel, made of sheet metal plate, has similar form to Witoszyński's nozzle, what allows obtaining an equal speed disposition in the inlet section. Such form of this part has a task to stabilize the flow speed in the whole tunnel section

and eliminate of possible turbulences arising by the inlet. Next element of the wind tunnel is the measurement section of dimensions 300x300 mm, made of transparent perspex (enabling observations of the effect course). The researched sample was placed in special formed cut-out in the tunnel base. It causes, that the sample surface is situated on the same level as the base of the installation. The cut-out allows placing the sample of dimensions 300x300x50 mm. Further the air is carried away through the 1,5 m long tunnel segment by using of axial-flow fan. In front of the cell with sample a measurement of the air stream speed was made. The measurement was made in assistance of hot-wire anemometer, which can be optionally relocate both in the vertical and horizontal surface. For assurance of fluently speed regulation of the air stream flow, the fan engine was connected to the frequency current converter. It allowed achieving an effective speed of the air flow in the tunnel, in the range from 0 to 3 m/s. The measurement place was also equipped with additional devices for measurements of partial vacuum in the measurements section, enabling its calibration.

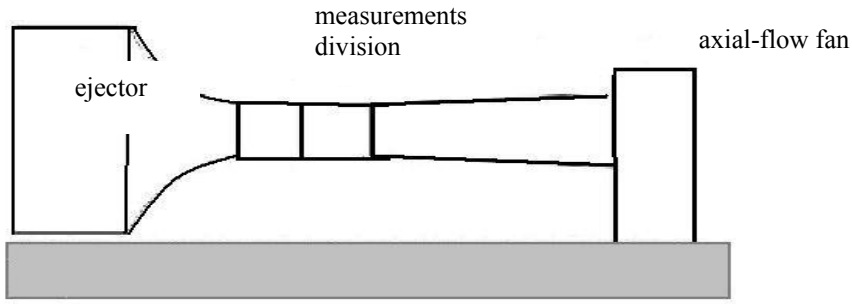

Figure 1. Ideological scheme of the measurements place – wind tunnel

The determination of the conditions in the wind tunnel – flow speed, was carried out in accordance with polish standard PN – ISO 5221 from December 1994 "Air distribution and separation. Measurement methods of the air stream flow in the conduit". The dusting intensity was defined in assistance of Aspirator AP-2000EX, serving to drawing of air samples, impure by the industrial dust from the respiration zone of the laboratory assistant on his work-stand and other tests from the range of the flow from 0,6 to 2,21/min.

RESULTS AND DISCUSSION

Researched materials were characterised by similar humidity from 12,9% in granulated feed (PF) to 9,9% in wheat straw (WS).

In the consequence of dusting test there was stated, that by the lowest speed of air movement – 0,15 m/s only mineral sorbent – halloysite (HA) has dusted. The dust emission from halloysite by this air movement speed amounted to 50 mg/m^3 (fig. 2). By the air movement speed of 0,2 m/s dust emission only for halloysite was still noted. The amount of dust emitted from halloysite has risen of over 30 mg/m^3. On the ground of over presented results it was stated that humidity of this material should be raised to limit its emissive properties. Such a test wasn't undertaken because potential material use of this kind in animal production has in view to utilize their sorptive properties in regard of limitation of odour formative gases emission from the litter. Every quantity growth of water in researched materials would cause decrease of their sorptive potential.

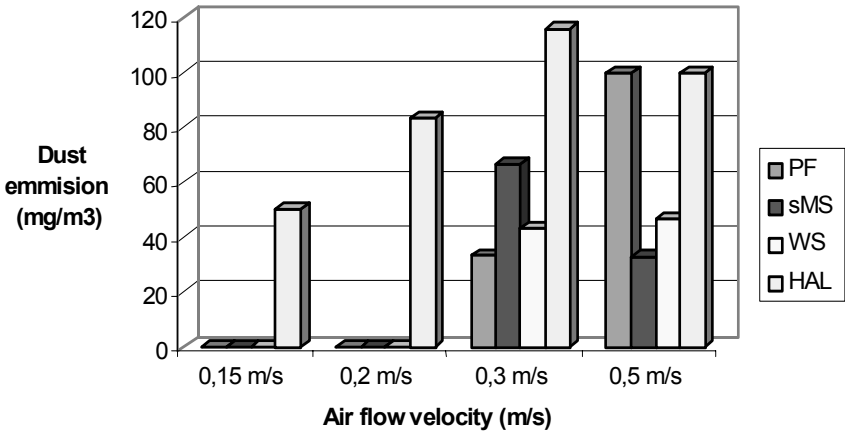

Figure 2. Dusting level of researched materials by determinate speed of air movement in the tunnel.

Defining the emission level of total dust from researched materials by the highest air movement speed in livestock houses, recommended in the winter time (0,3 m/s), there was stated, that the biggest dust amount provided halloysite, in quantity of 116,16 mg/m, then straw *Miscanthus sinensis* – sMS, on the level of 50–60 mg/m^3. In case of other materials emission was on the level of about 30 mg/m^3. For the air movement speed of 0,5 m/s (the highest acceptable in the summer time in the livestock buildings) no substantial changes in the quantity of emitted dust for straw and halloysite was stated. In case of the test of 0,5 m/s for granulated feed threefold growth of dust amount in comparison to the test for air movement in the tunnel, on the level of 0,3 m/s, was noted.

An exception was also the Chinese Miscanthus. The quantity of dust supplied by this material has been reduced of 50% in relation to test performed by the speed of 0,3 m/s. That chance results very likely from great heterogeneity of the material that is why the fine elements were left on the bottom of the cell and big parts of stalks has covered them.

On the grounds of obtained results it can be stated, that the biggest dust emission during the research has characterised the halloysite, hence its usage as a supplement for litter to limit the emission of toxic gases to the air can enlarge the air dusting of livestock rooms. From among of tested materials, used commonly in the technology of poultry production, the greatest "deliverer" of dust to the room air, is proved to be the feed, especially by higher speeds of the air movement. Nakaue at all [1981], making studies on the quantity of elements identified in the dust from the air of layer hen room have stated, that the feed is one of main air dusting sources in buildings of cage-keeping system. Litter materials can be also serious dust emitter in the livestock rooms what confirm studies of Dobrzański at all [1988]. On the basis of obtained results the authors have acknowledged litter as main dust source in the rooms for poultry, held on bedding, and the number of microorganisms in the air of such room is conditional on the level of its dusting. Additionally it was stated, that the air dusting size in rooms of this kind depends on the air humidity, temperature, but above all from activity of birds which are held there.

REFERENCES

1. Dobrzański Z.: 1999, Materiały szkoleniowe. Specjalizacyjne Studium Podyplomowe dla Lekarzy Weterynarii: "Choroby drobiu oraz ptaków ozdobnych", Zeszyt 1, Wyd. wew. Katedra Epizootiologii i Klinika chorób Zakaźnych Wydziału Medycyny Weterynaryjnej AR we Wrocławiu.
2. Dobrzański Z., Kołacz R.: 1996, Przewodnik do ćwiczeń z zoohigieny., Skrypt AR, nr 412, wydanie III.
3. Dobrzański Z., Gaweł A., Mazurkiewicz M., Latała A.: 1988, Kształtowanie się mechanicznych, chemicznych i biologicznych zanieczyszczeń powietrza w fermowych wychowalniach kurcząt lini nieśnych., Medycyna Wet., 4, (44), 236–238.
4. Hinz T., Linke S.: 1998, A comprehensive experimental study of serial pollutants In and emissions from livestock buildings. Part 2: Results., J. Agric. Engng. Res., 70, 119–129.
5. Homidan A. Al., Robertson J. F., Petchey A. M.: 2003. Review of the effect of ammonia and dust concentration on broiler performance., World's Poultry Science Journal, 59, 340–349.
6. Nakaue H. S., Koelliker J. K., Buhler D. R., Arscott G. H.: 1981. Distribution of inorganic elements in poultry house dust., Poultry Sci., 60, 1386–1391.
7. Olendrzyński K., Dębski b., Kargulewicz I., Skośkiewicz J., Fudała J., Hławiczka S., Cenowski N.: Warszawa 2003, Inwentaryzacja emisji zanieczyszczeń powietrza za rok 2001 na potrzeby statystyki krajowej i zobowiązań międzynarodowych w ramach w ramach Konwencji w sprawie transgranicznego przenoszenia zanieczyszczeń powietrza na dalekie odległości., wyd. Krajowego Centrum Inwentaryzacji Emisji, Instytutu Ochrony Środowiska.
8. Robertson A. P., Hoxey R. P., Demmers T. G. M., Welch S. K., Sneath R. W., Stacey K. F., Fothergill A., Filmer D., Fisher C.: 2002, Commercial-scale studies of the effect of broiler-protein intake on aerial pollutant emission., Biosystems Engineering, 82, 217–225.
9. Wathes C. M., Phillips V. R., Holden M. R., Sneath R. W., Short J. L., White R. P., Hartung J., Seedorf J., Schroder M., Linkert K. H., Pedersen S., Takai H., Johnsen J. O., Groot Koerkamp P. W. G., Uenk G. H., Metz J. H. M., Hinz T., Caspary V., Linke S.: 1998, Emissions of aerial pollutants in livestock buildings in northern Europe: overview of a multinational project., J. Agric. Engng. Res., 70, 3–9.
10. Wathes C. M.: 1994. Air and surface hygiene. In: Livestock Housing. Eds. Wathes C. M. And Charles D. R., CAB International, Wallingford, 123–148.
11. Wathes C. M., Randall J. M.: 1989, Aerosol sampling in animal houses, Commision of the European Communities, Luxemburg, Eur. 11877.