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REMOVAL OF MICROBIAL CONTAMINANTS FROM PIG HOUSE AIR USING BIOFILTER ORGANIC MEDIA*

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Abstract

The objective of the study was to assess efficiency of biofiltration of air microbial contaminants in a pig facility. A biofilter was fitted to the outlet of the ventilation system of a litter-bed pig house. The microbiological study of the fattening house air demonstrated very high contamination. Air bacterial count in the piggery averaged 8.3×10^6 cfu/m^3. The dominant pollutants in the analysed air samples were Gram-positive cocci of *Staphylococcus*, *Micrococcus* and *Rhodococcus* genera and *Corynebacterium* of *Brevibacterium* genus. Mean fungal count recovered from the piggery air was 1.9×10^5 cfu/m^3. In the analysed air of the litter-bed pig house, the fungi of *Penicilium*, *Scopularopsis*, *Ulocladium* and *Aspergillus* genera were identified most frequently. During the air biofiltration process, mean bacterial reduction was 76.5% for medium A and 30.4% for medium B. Average fungal reduction for both biofilter beds was 69% and 63%, respectively. After the biotreatment process, complete absorption/reduction of *Rhodococcus*, *Brevibacterium*, *Neisseria*, *Pantoea*, *Pseudomonas* bacteria and *Scopularopsis*, *Mucor* and *Paecilomyces* fungi was observed.

Key words: piggery, bioaerosol, prevention, biofilter

Farm buildings create a specific microclimate favouring a wide variety of microorganisms to populate and multiply in. These microorganisms are predominantly saprophytes, yet a part of them may show pathogenic or conditional pathogenic characteristics. Air microflora composition depends primarily on the health status of maintained animals, sanitary and hygiene conditions, and quality of feedstuffs and bedding provided (Dutkiewicz et al., 1994). Studies show that mesophilic bacteria are the most prevalent microorganisms present in the pig house air, averaging 58% of total bacteria numbers. The predominant bacteria are those making up the physiological flora of the animal skin and mucous membranes, i.e. *Staphylococcus*, *Corynebacterium* and *Streptococcus* species (Dutkiewicz et al., 1994). However, the

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molecular biology methods applied by Nehme et al. (2008) showed that a major source of microbial contamination of the pig unit air is swine manure, which Zhu (2000) found to be dominated by Gram-positive cocci of *Streptococcus*, *Peptostreptococcus* and *Staphylococcus* species as well as *Lactobacillus*, *Escherichia* and *Bacillus* bacteria. Predicala et al. (2002) noted that in the pig house air, Gram-positive bacteria were mainly represented by *Aerococcus*, *Micrococcus* and *Bacillus* species. As for Gram-negative bacteria isolated in the pig house bioaerosol, the presence of *Escherichia coli*, *Enterobacter agglomerans*, *Acinetobacter baumanni* (Zucker and Müller, 2000), *Acinetobacter calcoaceticus*, *Klebsiella pneumonia*, *Klebsiella oxytoca*, *Erwinia herbicola* and *Enterobacter cloacae* (Dutkiewicz et al., 1994) was reported most often in addition to *Moraxella* and *Pseudomonas* species (Predicala et al., 2002). There may also occur some pathogenic bacteria such as *Staphylococcus aureus*, *Streptococcus suis*, *Pasteurella* spp., *Bordatella* spp., *Actinobacillus* spp., *Salmonella* spp. or *Mycoplasma* spp. (Zhu, 2000; Pejsak and Truszczyński, 2005).

Fungi are a common component of bioaerosols in the pig house. Their quantity and composition depends on many factors, including animal welfare (temperature, humidity, ventilation, etc.) (Chang et al., 2001). Chmielowiec-Korzeniowska (2011) found that the most common moulds in pig house air are *Aspergillus* and *Penicillium* species, followed by *Alternaria*, *Fusarium*, *Botryotrichum*, *Verticillium* and yeasts. In Swedish (Donham, 1991) and Taiwanese studies (Chang et al., 2001), the fungi identified in the pig unit air most often were those of *Cladosporium* species. Chang et al. (2001) reported that in the spring months, this species may account for over 90% of the isolated fungi.

All these microorganisms are individual constituents of indoor bioaerosols, especially organic dusts. They are vented away to the outside in high concentrations. Although the effects of the exposure to pathogens transported with the bioaerosol are still open to discussion, it has been proven that in some cases, the airborne pathway is a key route of disease spread (Pejsak and Truszczyński, 2005). Transport of airborne pathogens depends on many factors and mechanisms. A critical role is played by species, microbe strain as well as air relative humidity, temperature, isolation, season, air flow and land topography. Farm size is believed to be a major risk factor for increased airborne infection rate as larger farms of pigs pose more serious hazards (Pejsak and Truszczyński, 2005).

One method that has been used to prevent the release of airborne biological agents is biofiltration, which is used to purify the air of chemical pollutants (Chmielowiec-Korzeniowska et al., 2007). The aim of the present research was to assess the efficiency of biofiltration of air microbial contaminants in the pig house using organic biofiltration materials.

Material and methods

The efficiency of microbial air contamination control during biofiltration was evaluated in a litter-bed pig house of 44.0 × 12.2 m dimensions with an average stock of 650 fatteners. The animals were housed on deep-litter bedding. Faeces removal

and pen cleanup took place after each production cycle. Feeding system was fully automated and mechanized.

A biofilter was installed in the ventilation outlet at the pig facility (Figure 1). The biofiltration device included the following components: a high-pressure blower of 800 m^3/h capacity, air humidifier and biofiltration chamber. The biofiltration chamber was divided into two independent parts (1.5 × 2.0 × 2.5 m) to facilitate the simultaneous assessment of biofiltration properties of two different materials. The filtration material included compost soil (40%) and peat (40%) mixed up with straw (20%) – medium A, and mixed up with oak chips (10%) and crushed bark (10%) – medium B.

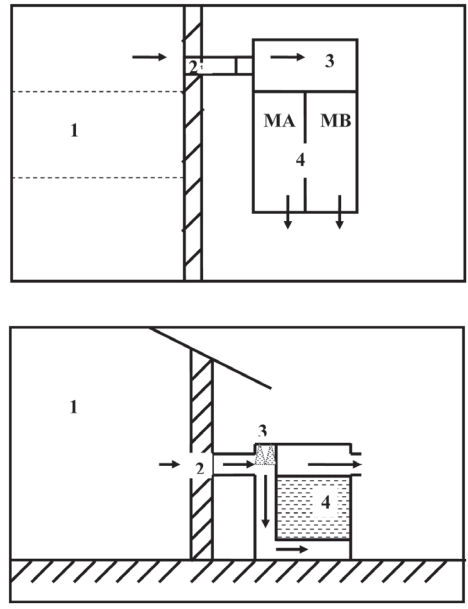

Figure 1. Diagram of installation biofilter: 1 – pig house, 2 – fan, 3 – humidifier, 4 – biofiltration chamber, MA – medium A, MB – medium B

The study commenced 30 days after biofilter start-up, that is after the bed medium stability period. Seven series of experiments were carried out during the 6-month course of the study. In each series of experiments, six air samples were collected: two in the air intake duct of the biofilter in the pig house (P1), and four at the air outlet duct, i.e. two in each biofiltration chamber, medium A (P2) and medium B (P3). Biofiltration removal efficiency was estimated based on the results obtained before and after the biofiltration process.

The air microbial contamination was determined by the aspiration method in compliance with the Polish standard PN-EN 13098:2007 using a GilAir 5 air sampling device (Sensdidyne, Inc., Clearwater, USA). Total count of bacteria and microscopic fungi was determined by means of the dilution plate technique. Inocula were spread over the surface of tryptic soy agar (TSA) (BTL sp. z o.o. Poland, Łódź) me-

dium enriched with 5% sheep blood to determine total bacteria load, while the malt extract agar (MEA) (BTL sp. z o.o. Poland, Łódź) medium was applied to establish total microscopic fungi count. The air samples inoculated onto the TSA medium were incubated for 7 days at 37°C (1 day), 22°C (3 days) and 4°C (3 days), whereas onto the MEA medium at 30°C (4 days) and 25°C (3 days). After incubation, the microbial colonies grown on each medium were initially studied macro- and microscopically. Then, the number of individual morphological types was determined and presented with colony-forming units (cfu) in m^3 of air. The recovered bacteria were identified according to microscopic appearance and their biochemical characteristics by means of API tests (bioMerieux Poland, Warsaw).

The microbiological examination of the piggery air was made concurrently with the investigation on the microbiological and physicochemical properties of the media and filtration water. The samples of biofiltration material and biofiltration water (0.5 kg/l) for microbiological analyses were collected four times into sterile containers. At each test series, 4 biofiltration material samples were collected (2 from medium A and 2 from medium B), which were mixed up to constitute the test sample.

Microbiological determination of the filtration medium and filtration water was performed by means of serial dilution plates, with the surface inoculation onto suitable growth media. Mesophilic and psychrophilic bacteria were inoculated onto agar media (BTL sp. z o.o. Poland, Łódź) and incubated at 37°C and 22°C for 24 h and 72 h, respectively. Fungi inoculated on Sabouraud medium (BTL sp. z o.o. Poland, Łódź) were incubated at 26°C for 5 days, actinomycetes on "Agar for Actinomycete" (Scharlau Chemie S.A. Barcelona, Spain) with supplemental nystatin at 26°C for 7 days, and proteolytic bacteria on Frazier gelatin medium at 26°C for 7 days. After incubation, the grown colonies were calculated assuming that one bacterial cell produces one colony.

The temperature of the filter material was determined using an electronic thermometer (Elmetron, Zabrze, Poland). The pH was measured using a CP-104 pH-meter (Elmetron, Zabrze, Poland). Moisture content was determined gravimetrically.

The chemical determination of filtration water included the content of ammoniacal, nitrate and nitrite nitrogen, phosphates, dissolved oxygen, pH and electrolytic conductance. The analysis was performed with a C200 multicolorimeter (Hanna Instruments, Lingolsheim, France) and CC-315 conductometer (Elmetron, Zabrze, Poland).

The determination results were presented in tables, with arithmetic mean (M) and standard deviation (SD). The data obtained was analysed statistically by the Wilcoxon nonparametric test with SAS v.9.1 statistical packet.

Results

In this study, the level of bacteria and fungi in the piggery air was of the order of 10^6 cfu/m^3 and 10^5 cfu/m^3, respectively (Table 1). Cocci belonging to the species *Staphylococcus* (23.1%) and *Micrococcus* (19.4%) were the main components of the air bacterial flora of the piggery. Gram-negative bacteria accounted for 2.8% of the total bacterial population. The main constituents of the airborne Gram-negative flora

were *Acinetobacter jejuni* and *Pantoea* sp. Among the fungi, the most frequent were *Aspergillus* (68.4%), *Ulocladium* (12.6%) and *Penicillium* (7.2%) species.

Table 1. Average bacteria and fungal count in the air before and after biofiltration

Species	Before biofiltration (P1) N = 7, n = 14		After biofiltration			
			medium A (P2) N = 7, n = 14		medium B (P3) N = 7, n = 14	
	M	SD	M	SD	M	SD
Bacteria ($\times 10^4$ cfu/m^3)						
Total bacteria count, including:	833.9 a	1174.3	196.4 a	451.5	579.9 a	761.6
Gram-positive bacteria ($\times 10^4$ cfu/m^3)						
Staphylococcus lentus	192.3 a	340.0	8.8 a	13.8	283.4	534.2
Micrococcus sp.	161.6	586.2	166.9	461.3	140.9	262.1
Rhodococcus sp.	114.3	346.6	0.0	0.0	0.0	0.0
Brevibacterium sp.	101.3 a	46.4	1.6 a	2.8	11.7	29.1
Kocuria varians	84.5 a	27.5	1.3 a	2.9	46.1	129.5
Staphylococcus xylosus	46.8	135.1	0.3	0.6	3.1	8.8
Corynebacterium sp.	34.3	124.5	0.1	0.3	0.0	0.0
Microbacterium sp.	33.2	52.9	2.4	5.8	62.5	176.8
Cellulomonas sp.	1.7	2.8	1.8	5.0	0.0	0.0
Gram-negative bacteria ($\times 10^4$ cfu/m^3)						
Acinetobacter jejuni	9.0	81.9	0.0	0.0	31.3	88.4
Pantoea sp.	7.0	0.3	0.0	0.0	0.0	0.0
Neisseria polysaccharea	5.5	2.0	0.0	0.0	0.0	0.0
Pseudomonas alcaligenes	1.5	2.0	0.0	0.0	0.0	0.0
Others	40.9	27.0	13.2	31.8	0.9	2.3
Fungi ($\times$ 103 cfu/m^3)						
Total fungal count, including:	198.9 a	218.7	53.1 a	51.0	64.6	70.7
Aspergillus sp.	136.1	219.5	36.5	71.8	34.4	73.4
Ulocladium sp.	25.0	74.7	2.1	3.9	14.6	41.2
Penicillium sp.	14.4	17.4	8.3	10.9	9.4	9.4
Scopularopsis sp.	12.2	31.6	0.0	0.0	0.0	0.0
Cladosporium sp.	5.6	15.0	4.2	6.3	1.0	2.9
Trichoderma sp.	2.8	8.7	0.0	0.0	1.0	2.9
Mucor sp.	1.7	4.7	0.0	0.0	0.0	0.0
Paecilomyces sp.	1.1	4.3	0.0	0.0	0.0	0.0
Botritis sp.	0.0	0.0	2.1	3.9	3.1	6.2
Acremonium sp.	0.0	0.0	0.0	0.0	1.0	2.9

N – number of series, n – number of samples, a…– values marked with the same letters differ significantly at $P \leq 0.05$.

The difference between the concentration of bacteria and fungal count measured at the inlet and outlet duct of medium A was statistically significant ($P \leq 0.05$).

The number of *Staphylococcus lentus*, *Brevibacterium* sp. and *Kocuria varians* decreased significantly after biofiltration. Due to great fluctuations in the determined concentrations of other microorganisms, the difference between the levels prior to and after biofiltration was not statistically significant. In medium B statistical comparison revealed a significant decrease in the concentration after biofiltration only for total bacteria count.

On the basis of the mean concentrations of the pollutants determined prior to biofiltration and after biotreatment, the mean removal efficiency was calculated for each bed used in the investigation (Figures 2–5).

Average bacterial reduction rate was 76.5% for the straw-supplemented medium A and 30.4% for the oak chips and crushed bark medium B (Figure 2). Total fungal count in the air leaving the biofilter declined by 69% for medium A and by 63% for medium B. More efficient treatment of Gram-positive bacteria was found for medium A compared to medium B (Figure 3). Very good results were obtained in medium A for Gram-negative bacteria, while trace amounts of *Acinetobacter jejuni* were noted at the outlet of medium B (Figure 4).

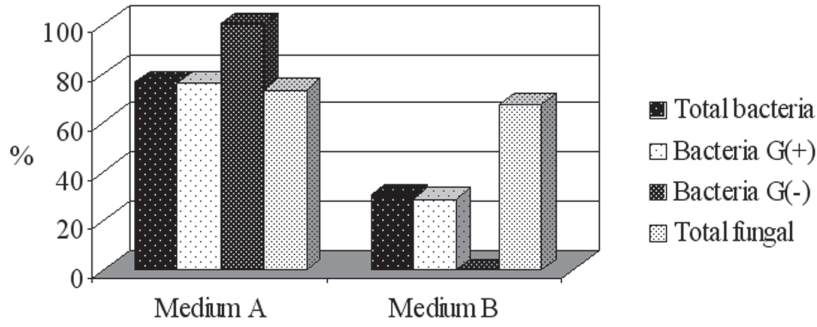

Figure 2. Efficiency values for reduction of microbiological pollutants by the biofilter media tested throughout the experiment (%)

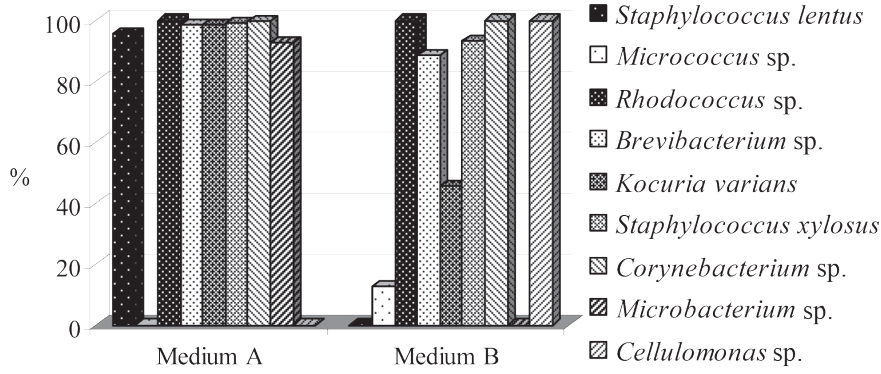

Figure 3. Efficiency values for reduction of Gram-positive bacteria by the biofilter media tested throughout the experiment (%)

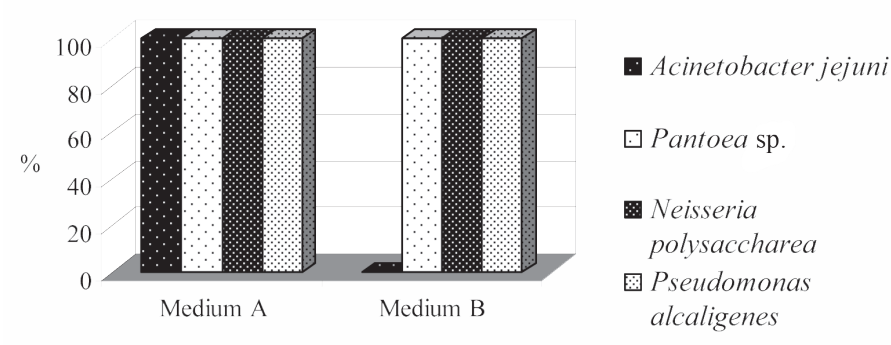

Figure 4. Efficiency values for reduction of Gram-negative bacteria by the biofilter media tested throughout the experiment (%)

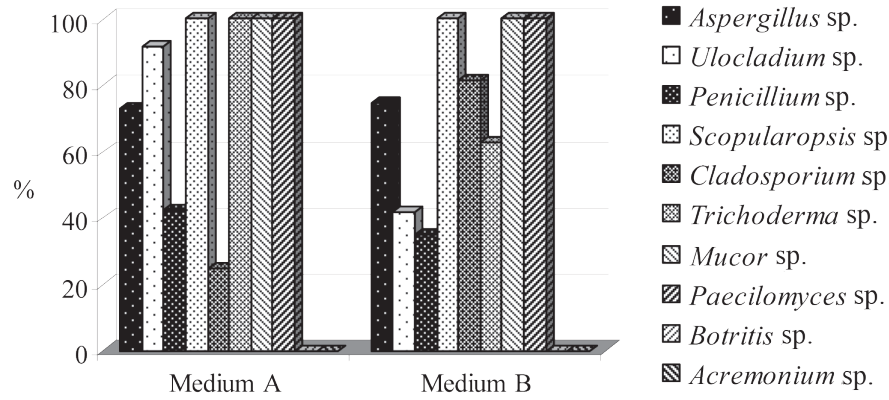

Figure 5. Efficiency values for reduction of fungi by the biofilter media tested throughout the experiment (%)

Among the fungi, the complete elimination was achieved for *Scopularopsis*, *Mucor* and *Paecilomyces* species (Figure 5). The straw-supplemented medium was more effective for the reduction of *Trichoderma* and *Ulocladium* fungi, whereas that with oak chips and bark component – for *Cladosporium* fungi removal.

Monitoring of the physicochemical properties of the media showed stability of the determined parameters (Table 2). Throughout the study period, the temperature of both media was roughly similar and did not exceed 23°C. The relative humidity of both media was within the optimal limits and averaged 50–68%. The investigated media approached the neutral reaction and ranged between 5.9 and 6.6. There was an increasing concentration of ammonium N-NH^{4+} and nitrate N-NO_3 ions in the filtration water.

Table 2. Physicochemical properties of filtration media and filtration water

Parameter	Medium A N = 7, n = 14			Medium B N = 7, n = 14			P-value
	M	SD	range series I – series VII	M	SD	range series I – series VII	
Filtration medium							
Moisture (%)	55.3	3.1	58.5–60.4	56.6	6.3	68.4–59.3	0.646
Temperature (°C)	22.2	2.8	16.0–24.0	21.4	2.4	18.0–22.0	0.605
pH	6.3	0.2	6.5–6.3	6.3	0.2	6.3–6.4	0.826
Filtration water							
Temperature (°C)	22.7	2.4	19.2–19.2	22.8	2.6	19.2–19.2	0.976
pH	6.7	1.0	7.7–7.1	6.9	0.6	7.0–6.8	0.650
Electrolytic conductance (µS/cm)	3034.3	787.6	2050.0–2510.0	3422.9	1286.0	1286.0–2960.0	0.519
Dissolved oxygen (mg/l)	7.2	2.0	10.2–7.8	6.7	2.1	8.8–7.1	0.708
Ammonia (mg/l)	0.8	0.7	0.9–0.8	0.7	0.5	0.7–0.9	0.706
Nitrates (mg/l)	1.3	1.0	2.7–2.5	1.5	1.1	2.0–2.0	0.756
Nitrites (mg/l)	0.1	0.1	0.3–0.0	0.1	0.0	0.0–0.0	0.661
Phosphates (mg/l)	0.6	0.9	0.0–0.7	0.3	0.3	0.5–0.3	0.408

N – number of series.
n – number of samples.

Table 3. Microbiological properties of filtration media (× 10^3 cfu/g)

Total count	Medium A N = 7, n = 14			Medium B N = 7, n = 14			P-value
	M	SD	range series I – series VII	M	SD	range series I – series VII	
Mesophilic bacteria	295.6	249.0	39.5–244.5	164.5	130.1	32.5–237.0	0.276
Psychrophilic bacteria	208.4	341.2	67.0–158.0	192.4	270.1	57.0–293.5	0.928
Proteolytic bacteria	32.2	74.0	1.0–1.0	13.3	25.0	2.5–4.5	0.569
Actinomycetes	11.6	14.1	0.0–4.0	29.6	25.6	2.5–20.0	0.142
Fungi	18.9	14.1	27.5–47.5	18.9	8.4	20.0–27.0	0.992

N – number of series.
n – number of samples.

Some minor differences were observed between the biofilter materials in the case of microbiological determinations (Table 3). The straw-supplemented medium (medium A) appeared to be more conducive for microorganism growth compared to that with oak chips and bark medium (medium B). These differences were not statistically significant.

Discussion

The present research carried out in the pig house showed that average concentration of bacteria and fungi in the air exceeded the sanitary standards. A similarly high level of microbial contamination in the piggery air was reported by Taiwanese (Chang et al., 2001), Polish (Dutkiewicz et al., 1994) and Norwegian researchers (Eduard et al., 2004). The results obtained appeared to be higher than the threshold values set up by Donham (1991) who stated that total microbial count in the pig house air should not exceed 105 cfu/m^3. Concentration of total bacterial load in both chambers (with medium A and B) also surpassed the zoohygienic levels established for animal health standards (8.0×10^4 cfu/m^3) as well as the sanitary standards for occupational safety and health of employees (2.0×10^5 cfu/m^3 for bacteria, 1.0×10^4 cfu/m^3 for fungi) (Krzysztofik, 1992). A pollution level established was markedly affected by the litter-bed management system in the pig facility. This finding is consistent with the study of Chang et al. (2001), who demonstrated that air contaminated with dust of grass has higher microbial pollution rate, with prevailing crop plant microorganisms. Like in the study by Chang et al. (2001), significant contribution to the total pool of air microorganisms was made by Gram-positive bacteria. Gram-negative bacteria accounted for 2.7% and included *Neisseria*, *Acinobacter*, *Pseudomonas* and *Pantoae* species. Chang et al. (2001), Zucker and Müller (2000), and Dutkiewicz et al. (1994) report a varied percentage of Gram-negative bacteria that reached 0.04%, 5.2% and 8.0%, respectively. Chang et al. (2001) associate these differences with, among others, different test protocols and analytical samplers used for the determination. In the present study, out of the Gram-negative bacteria isolated in the pig house bioaerosol the most abundant were *Acinetobacter* and *Pantoea* species. These bacteria constitute a major source of endotoxins in the agricultural dust. According to the classification of Dutkiewicz et al. (2007), the bacteria belong to Hazard Group 2 and may produce allergic and immunotoxic reactions induced by inhaled bacterial endotoxin (LPS). In addition, they contribute to acute pneumonitis development and are a cause of allergic lung diseases.

A significant risk factor for increased incidence of respiratory disorders are *Aspergillus* fungi, which form the most numerous mould group (68.4%) in the experimental pig facility.

The waste gas from the pig house with deliberately introduced microbial contaminants entered the biofilter via the ventilation system. The pollutants passing through the biological filter medium underwent the microbial metabolic activity and as a consequence, their total numbers in the effluent airstream were markedly reduced.

Average removal rate of bacteria and fungi was higher in the straw-supplemented medium (76.5% and 69.0%) than in the medium with oak chips and crushed bark (30.4% and 63.0%).

Similar results were obtained by Seedorf and Hartung (1999). The biotreated air from a pig house was found to show 71% reduction in the numbers of mesophilic bacteria and fungi. The research findings of Tymczyna et al. (2007) indicate that biofilter installation in the ventilation outlet of a hatching hall results in nearly complete elimination of Gram-negative bacteria. Martens et al. (2001) reported that for pig unit air biofiltration, removal rate averaged 25% to 90% for bacteria and less than 60% for fungi. However, the authors reported very high elimination efficiency (over 90%) of microbial metabolites, including endotoxins and microbial volatile organic compounds (MVOC).

During the research period, the airstream forced to the biofilter also contained the introduced bacteria of immunotoxic and allergizing properties (*Pseudomonas alcaligenes*, *Pantoea* sp. and *Corynobacterium* sp.). After the biotreatment process, there was observed complete absorption/reduction of Gram-positive bacteria of *Rhodococcus*, *Brevibacterium* species and Gram-negative bacteria of *Neisseria*, *Pantoea* and *Pseudomonas* species as well as a notable decrease in *Corynobacterium* bacteria load. The study carried out with medium A revealed uniform susceptibility to the biological degradation of *Staphylococcus lentus*, *Brevibacterium* sp. and *Kocuria varians* bacteria. As for medium B, the numbers of microorganisms that entered the medium were observed to decline, but the differences were statistically non-significant.

Among the fungi, the complete elimination in both media was achieved for *Scopulariopsis*, *Mucor* and *Paecilomyces* species. The straw-supplemented medium was more effective for the reduction of *Trichoderma* and *Ulocladium* fungi, whereas that with oak chips and bark component – for *Cladosporium* fungi removal.

Wide fluctuations were noted throughout the process of microbial contaminants elimination. In the single series, the outlet air from biofiltration medium B exhibited rising microbial counts, including *Staphylococcus lentus*, *Microbacterium* sp., *Acinetobacter jejuni* bacteria. Whereas in the effluent released from medium A, bacteria of *Micrococcus* and *Cellulomonas* species were isolated. Moulds of *Botritis* and *Acremonium* species were identified from the biofiltering materials of both media. As the other studies indicated, the material applied in this research naturally harbours a part of these microorganisms. Martinotti et al. (1999), who studied the compost microflora composition, in addition to *Achromobacter*, *Acinetobacter*, *Bacillus*, *Commomonas*, *Clostridium* and *Flavobacterium* recovered *Cellulomonas*, *Pseudomonas* and *Staphylococcus* bacteria most frequently. *Cellulomonas* sp. also is a major species of bacteria isolated from soil, while in a soil contaminated with aromatic compounds, there multiply bacteria capable of their degradation, i.e. *Pseudomonas* and *Acinetobacter*. Interestingly, these bacteria were also found in the pig unit air.

Similar effects were described by Seedorf and Hartung (1999). A bioscrubber they applied for the decontamination of air vented from a pig facility appeared to be an additional source of microbial pollution. Likewise, Martens et al. (2001), who studied biofiltration of the pig house air reported elevated numbers of microorgan-

isms in the effluent air. Removal rate fluctuated between –23.1% and 96.2%, with the mean value for the entire research period being 66.4%. Zilli et al. (2005) stated that microbial contamination emission at biofiltration is dependent primarily on the amount of air treated and the type of packing material used.

The research findings and results discussed above are reasonably supportive of the air biofiltration technology application in a pig unit to reduce microbial contaminant load. Importantly, this technology may be considered as a key element of the biosecurity programme. Finally, it has been proven that the properties of both media under study ensured the effective and stable biodegradation process. The physicochemical and microbiological properties of both media showed stability of the determined parameters, favourable to effective microbial colonization. The use of straw as a filter material created better conditions for growth of bacteria in the medium and prevented the blowing of the bacteria. Thus, they increased the efficiency of biofiltration.

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LESZEK TYMCZYNA, ANNA CHMIELOWIEC-KORZENIOWSKA, JOANNA RACZYŃSKA, AGATA DRABIK

Oczyszczanie powietrza chlewni ściołowej z mikrobiologicznych zanieczyszczeń przy zastosowaniu biofiltracyjnych złóż organicznych

STRESZCZENIE

Celem przeprowadzonych badań była ocena skuteczności biofiltracji mikrobiologicznych zanieczyszczeń powietrza w chlewni. Biofiltr zainstalowano na wylocie powietrza z urządzeń wentylacyjnych chlewni ściołowej.

Przeprowadzona ocena mikrobiologiczna powietrza tuczarni wykazała bardzo wysokie zanieczyszczenie powietrza. Średnia liczba bakterii w powietrzu chlewni wynosiła $8,3 \times 10^6$ jtk/m^3. W badanym powietrzu najliczniej występowały gram-dodatnie ziarniaki z rodzaju *Staphylococcus*, *Micrococcus* i *Rhodococcus* oraz maczugowce należące do rodzaju *Brevibacterium*. Średnia liczba grzybów w powietrzu chlewni wynosiła $1,9 \times 10^5$ jtk/m^3. W badanym powietrzu chlewni ściołowej najczęściej identyfikowano grzyby z rodzaju *Penicilium*, *Scopularopsis*, *Ulocladium* oraz *Aspergillus*. Podczas biofiltracji powietrza średnia redukcja bakterii dla złoża A wyniosła 76,5%, a złoża B 30,4%. Natomiast średni stopień redukcji grzybów dla obu złóż biofiltracyjnych wynosił odpowiednio 69% i 63%. Po biologicznym oczyszczaniu obserwowano całkowitą absorpcję/redukcję bakterii z rodzaju *Rhodococcus*, *Brevibacterium*, *Neisseria*, *Pantoea*, *Pseudomonas* i grzybów z rodzaju *Scopularopsis*, *Mucor* i *Paecilomyces*.