BIOFILTRATION OF VOLATILE INORGANIC COMPOUNDS IN THE HATCHERY

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ABSTRACT

The studies on the treatment of air vented from the hatchery hall were performed with a prototype enclosed biofilter.

The biofilter was fitted to the ventilating duct outlet of the room with 8 hatchers (AS-4H, Petersime, Zulte, Belgium) and 12 incubators (AS-4S, Petersime, Zulte, Belgium) with the input of 115 eggs. The biofilter of 2.0 x 1.8 x 1.8 m dimensions was composed of the following components: high pressure fan of 1500m^3/h maximal capacity, air humidifier and biofiltration chamber. This chamber was divided into three independent parts to facilitate the simultaneous assessment of the biofiltration properties of three different fillings – beds. In the present investigation, the following media were used: organic and organic – mineral. Removal efficiency of inorganic pollutants in the vented air was estimated by the ion chromatography method.

The performed research focused on the evaluation of control performance of air vented from the chicken hatchery room on the organic and mineral organic media in the enclosed container biofilter. The investigation proved very high treatment efficiency of the biofilter fitted at the ventilation system outlet, irrespective of a filter material applied. Reduction of total inorganic compounds reached nearly 40%, high in the case of ammonia and nitrite (nearly 50%),while low for nitrate (–73%).The best treatment properties (retaining) for air pollutants were recorded for the bed with bentonite.

Keywords: inorganic compounds, hatchery, biofiltration

OBJECTIVE

Animal production, in that poultry farms, also constitutes a source generating a broad range of chemical substances such as ammonia, hydrogen sulfide, mercaptans, indol, skatole, phenol as well as aldehydes, ketones, alcohols – the compounds showing the odorforming, toxic or even carcinogenous properties [Tymczyna & et. al., 2004a; 2004b]. Some of them undergo complex transformations in the air that can enhance their harmfulness.

Specificity of the off-gases produced at the animal breeding imposes the application of the methods that prove efficient towards such a broad spectrum of contaminants and the biotreatment methods for gas pollutants control satisfy this requirement. The biofiltration process is performed in so-called biofilters where the pollutants exposed to the direct contact with a bacteria population that naturally colonizes the filter material like, soil, peat compost or is deliberately introduced, are partly or completely degraded [Ramirez-Lopez et al., 2003].

The objective of the present work was to evaluate biotreatment performance of air contaminated with inorganic pollutants vented from the chicken hatchery hall during the biofiltration process.

METHODS

The study was conducted at the Poultry Hatchery in Dębówka, 20km south of Warsaw, Poland. The hatchery with annual output of 20 to 25 million Cobb and Ross meat hens, which represents 4% of the national production.

A bio-filter was installed in the ventilation outlet of the hatching room, which was equipped with 8 hatchers (AS-4H, Petersime, Zulte, Belgium) and 12 incubators (AS-4S, Petersime, Zulte, Belgium) with an input of 115th eggs. The bio-filter measured 2.0 x 1.8 x 1.8 meters, and included the following components: a high pressure fan with a maximum capacity of 1500 m^3/h; an air humidifier; and a bio-filtration chamber (constructed by the present authors).

The bio-filtration chamber was divided into three independent parts to facilitate the simultaneous assessment of bio-filtration properties of three different fillings – beds. The depth of the filter medium was between 1.2 and 1.4meters.

In this study, the following media were used: organic medium containing 50% compost and 50% peat – OM; organic-mineral medium containing 20% bentonite, 40% compost and 40% peat – BM; organic-mineral medium containing 20% halloysite, 40% compost and 40% peat – HM.

Six series of experiments were carried out during the 10mo course of the study. In each series of experiments, 10 air samples were collected: 4 in the air intake duct of the bio-filter – in the hatchery room, and 6 at the air outlet duct, i.e. 2 at each bio-filtration chamber.

The determinations of volatile inorganic compounds in the samples drawn into the sparger washers were performed in compliance with the Polish standards for ion chromatography using the liquid chromatograph Waters produce linked with Analytical Column IC-PAK Anion HR filled with Waters anion solvent combined with conductometer detector and UV.

The following statistical parameters were calculated on the basis of all of the research results: number of observations, arithmetic mean±standard deviation, arithmetic mean error and coefficient of variation. On the grounds of mean concentrations of the pollutants prior to and after the biofiltration application, a mean reduction rate of the pollutants could be calculated. Open biofilter removal efficiency was characterized by % reduction.

The mean levels of volatile inorganic compounds in the hatching room air were compared with the mean contamination levels in the air after bio-treatment using the Tukey's and Dunett's tests. The sampling site-specific coefficients for filter media efficiency were calculated using the Kruskal-Wallis nonparametric tests. The calculations were performed with SAS v. 9 and Statistica v. 6.0 software packages application.

RESULTS

Among the inorganic pollutants determined in the hatchery room, the presence of ammonia, nitrates, nitrites, chlorides, sulfides (Tab.1) was confirmed. The highest content was reported for ammonia (0,49 mg/m^3),while a concentration of other volatile pollutants appeared to be low, often at ion chromatography detection threshold (0.01 mg/m^3)

In the present research, there was observed a decrease of the inorganic compounds level after the biotreatment completion (Tab.1). The highest differences were found for the ammonia concentration whose content showed a clear decline in the air samples collected after the biofilter. Only the nitrates concentration in the air leaving the biofilter slightly increased on the organic bed (OM) and mineral with halloysite additive. The present study revealed a decreased content of the inorganic compounds after the biotreatment process (Table 1), the highest differences were noted in the ammonia concentration which exhibited a substantial fall in the air samples taken after the biofilter. However, only a nitrates level in the air leaving the biofilter was slightly elevated on the organic medium (OM) and mineral with a halloysite component (HM).The statistical analysis made with Tukey and Dunett tests did not reveal any significant differences between the concentration of the compounds recorded in the hall and their level after the biotreatment process completion.

Table 1. Inorganic compound concentration before and after biotreatment (mg/m^3)

COMPOUND TYPE			BEFORE	AFTER		
			hatchery hall	OM	HM	BM
Total		N	22	12	13	13
		M±SD	0,79±0,77a	0,55±0,66a	0,54±0,4 a	0,34±0,13 a
		min.	0,2	0,2	0,2	0,2
		max.	3	2,6	1,5	0,6
Identified:	ammonia	M±SD	0,49±0,81a	0,31±0,6 a	0,32±0,42 a	0,15±0,07 a
		Min.	0,1	0,1	0,1	0,1
		Max.	3	2,2	1,3	0,3
	nitrates	M±SD	0,01±0,04 a	0,03±0,12 a	0,02±0,06 a	0,00±0,0 a
		Min.	0	0	0	0
		Max.	0,2	0,4	0,2	0
	nitrites	M±SD	0,02±0,05 a	0,00±0,0 a	0,03±0,05 a	0,00±0,0 a
		Min.	0	0	0	0
		Max.	0,2	0	0,1	0
	chlorides	M±SD	0,19±0,15 a	0,14±0,13 a	0,12±0,12 a	0,13±0,14 a
		Min.	0	0	0	0
		Max.	0,6	0,4	0,4	0,4
	sulphates	M±SD	0,07±0,05 a	0,07±0,05 a	0,06±0,05 a	0,06±0,05 a
		Min.	0	0	0	0
		Max.	0,1	0,1	0,1	0,1

a,b.. – values in columns denoted with different letters differ significantly at p≤0,05 Tukey`s and Dunett`s tests
N – number of samples analyzed statistically
M±SD – arithmetic mean ± standard deviation

On the basis of the compared concentrations for each filter material, there was calculated its treatment performance (Table 2).The mean reduction percentage of all the identified inorganic compounds fluctuated within a broad range, i.e. from minimum minus 600% up to maximum – 100%.The highest treatment efficiency was recorded for nitrites (53,7%) while the lowest for nitrates (–73,7%).The nitrites removal rate appeared to differ statistically significantly (P≤0,05),subject to a medium investigated. The elimination level of the inorganic pollutants

averaged 39,8%,whereas a mean removal rate of all the identified inorganic substances showed considerable fluctuations from –600% to 100%.

Table 2. Percentage of inorganic compounds reduction [%]

COMPOUND TYPE		Mean			MB			MH			MO		
		M±SD	min	max	M±SD	min	max	M±SD	min	max	M±SD	min	max
Total		38,6±15,8	–600	91	57,0±36,3	–16,7	91	31,5±99,7	–216,7	68,5	30,1±25,9	–600	88,8
identified	ammonia	48±13,4	–500	90,5	70,2±38,5	–16,7	90,5	35,8±84,6	–183,3	66,7	37,2±21,9	–500	88,2
	nitrates	–73,7±53	–131	25,2	100±0	100	100	–69,2±31	–98,4	–38,7	–266,7±219	–500,5	100
	nitrites	53,7±86,8*	–100	100	100±0	100	100	–35,4±77	–100	33,3	100±0	100	100
	chlorides	32,5±37,5	–7,7	100	31,5±42,9	–7,7	100	39,6±37,3	7,7	100	25,8±41,6	–7,7	100
	sulphates	13,2±26	–16	34,2	15,4±8,6	8,4	25	15,4±8,6	8,4	25	8,3±10,5	–3,5	15,9

* statistically significant differences at $p \leq 0,05$ Kruskal-Wallis tests

M±SD – arithmetic mean ± standard deviation

Regarding all the tested media, the most beneficial properties for inorganic compounds bioreduction were shown for the bentonite supplemented medium (BM) (Table 2).This medium was characterized by the highest performance of a chloride removal rate, yet very low for nitrites and nitrates with negative values obtained. The lowest treatment efficiency was recorded for nitrites (–266,7%) in the organic bed (OM).

Degradation of the inorganic substances throughout the research period demonstrated a high variation (Fig.1). In I research series, the negative values for the inorganic substances (total) and ammonia contents were obtained that indicated a substantially higher number of these compounds after biotreatment than in the hatchery hall. However, the continued operation of the biofilter brought increased efficiency of biological treatment as in II research series the highest values for chlorides removal (100%) and ammonia reduction (83%) were determined. The nitrites decomposition, though, appeared to be some different as their highest elimination rate was established in 30wk of the biofilter work, that is III research period. The ammonia reduction level gradually declined in II research period, i.e from 10 wk of biofilter work till the experiment completion.

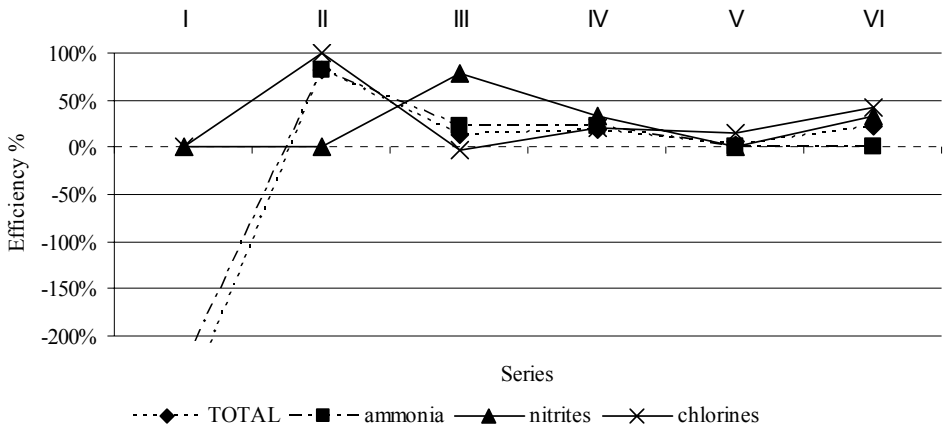

Figure 1. Percentage of inorganic compounds reduction at each series

CONCLUSIONS

The available Polish and foreign literature presents the simulation investigations of single compound degradation at the laboratory-scale [Classen et al.,2000]. However, the literature reviews only few studies on the biological waste gas treatment under the production conditions, where the generated volatile pollutants are not homogeneous but constitute a mixture of different chemical compounds The present work, though, is one of these attempts concerning the investigations undertaken in the real conditions. Despite a fact that the studies revealed very high variation of the VOC bioreduction which did not allow choosing statistically confirmed most beneficial medium, yet a following conclusion can be drawn. A bentonite supplemented filter material (20%) can seriously decrease pollutants amount released from this type of a contamination source, in particular ammonia and its degradation products.

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