ORIGINAL ARTICLES AAEM

Ann Agric Environ Med 2009, 16, 249–256

THE CONCENTRATION OF VOLATILE ORGANIC COMPOUNDS (VOCS) IN PIG FARM AIR

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Chmielowiec-Korzeniowska A: The concentration of volatile organic compounds (VOCs) in pig farm air. *Ann Agric Environ Med* 2009, **16**, 249–256.

Abstract: The aim of the study was to assess the level of air pollution by volatile organic compounds (VOCs) in a pig fattening house and in its vicinity. Air samples for chromatographic analysis were taken in the fattening house and in the vicinity of the farm. The air quality study shows that the level of organic gaseous pollutants was twice as high in the fattening house as in the atmospheric air. Almost a half of the organic gaseous pollutants determined in the fattening house air are listed among the harmful chemical factors in the work environment. Comparison of the results of the atmospheric air samples taken from the vicinity of the farm with the valid standards also shows very high levels of air pollution in the vicinity of the farm. A mean concentration of the sum of mercaptans, phenol, xylene, 2-methyl-1-propanol, and toluene exceeded their basic values determined in the atmospheric air stated for the calendar year [18].

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Key words: air pollution, volatile organic compounds, animal farm.

INTRODUCTION

Volatile organic compounds (VOCs) occur as by-products in numerous industrial processes and constitute a source of pollution of the natural environment. The main sources of the emission of volatile organic compounds in closed spaces are: paints, glues, linoleum, carpets, plaster, acoustic coating, detergents, and cigarettes [9, 13]. A part of them cause the sick building syndrome (SBS) in people [13].

In inventory buildings the main sources of the emission of VOCs are technological devices, feed, bedding, as well as animals. Most of the pollutants formed in these buildings have strong odorous properties. The compounds are formed during complex digestive processes (in the stomach and intestines), as well as during numerous conversions taking place in droppings lying under animals, and during their storing, utilization or usage as fertilizer in fields. The following compounds have been identified among them: volatile fatty acids, alcohols, aldehydes, amines, carbonates, esters, sulphides, disulfides, mercaptans, and heterocyclic nitrogen compounds [21].

The amount of released gases depends on the animal species, breeding system, and especially the number of animals kept in a building. In an hour, 1 m^3 of air is released into the natural environment by the ventilation system per every kilogramme of animal body mass. In other words, the higher the breeding potential the higher the amount of pollutants released into the environment.

The emission of odours and gaseous pollutants from the agricultural sources is a serious hazard to the environment, especially in areas with a high concentration of farm animals. First of all, this is an indicator of the sanitary state of air. However, it also causes a significant increase in the greenhouse effect (methane, carbon dioxide, nitrous oxide) and degradation, e.g. soil and surface water acidification (ammonia) [6]. The air polluted with volatile gases formed as a result of the decomposition of animal organic

Received: 30 January 2009
Accepted: 19 June 2009

substances may be toxic, irritant, or even carcinogenic. It is also important that these gases have an odorogenous character and are noxious to people because of their unpleasant smells. One should also bear in mind that residents of areas adjacent to breeding farms are exposed to the influence of a whole complex of airborne factors. Here, beside the chemical factors, biological factors and organic dust (which is their main transmitter) occur in high intensity [4, 5].

There is a lot of data concerning the emission of ammonia and hydrogen sulphide from breeding farms [8, 15, 16, 24], including pig farms [2, 10, 12, 20, 21]. Some part of the publications concern the emission of odorogenous compounds measured with olfactometric methods. Only few publications describe the analysis of gaseous pollutants released from farms, including pig farms, with a broad range of pollutants present in the air, measured with such sensitive methods as the chromatographic analysis.

The aim of the study was to assess the level of air pollution with volatile organic compounds (VOCs) in a pig fattening house and in its vicinity.

MATERIAL AND METHODS

The study was carried out at an individual pig farm with an average number of 105 Large Units (LU 500 kg). The monitoring of air pollution was performed in one of three inventory buildings, i.e. in the fattening house and in the vicinity of the farm.

Breeding conditions. The animals were raised in the bedding system on deep bedding removed after each breeding cycle. Feeding was fully automated and mechanized. The ventilation system was based on the mechanical subatmospheric pressure ventilation with fans placed on the ceiling.

Sampling site. Air samples for chromatographic analysis were taken in two places in the fattening house, i.e. (1) in the pigsty and (2) in the feeding passage, and in three places in the vicinity of the farm, i.e. (3) between the buildings, (4) in the manure storing place, and (5) in farmland adjacent to the farm, i.e. ca. 100 m from its boundaries.

The study commenced a week after the introduction of piglets to the fattening house, when the average body mass of the animals was 26.9 kg. The study was carried out until the end of fattening in three subsequent series to an average weight of 110 kg of the animals. Air samples were taken twice throughout two subsequent days in each study series. In total, there were 40 air samples taken in the series including five months from February to June.

Air chemical assessment. Organic air pollutants were determined with the gas chromatography method. Air samples (2–31) were taken with an electric pump into tedlar bags. The organic compounds contained in air samples were condensed by adsorbing them on samplers, type MX – 06 – 2131. Next, they were desorbed with the set for thermal desorption (TDV Model 890, Dynatherm, Analytical Instruments, Inc, Oxford, USA) on the chromatographic system (HP 5890 series II, Hewlett Packard, Santa Clara, USA) equipped with a selective flame photometric detector (FPD) operating with the S-filter with a wave length of 393 nm.

Two parallel paths of gathering data from the course of the chromatographic analysis were used: the digital path equipped with an integrator, type 3396, series II, and an analogue one equipped with an A/D conductor, interface and SRI PeakSimple (Torrance, USA) software, and III permeation standards DYNACAL by VICI Metronics (Washington, USA). Standard gaseous solutions (chromatograms) were prepared in a permeation chamber heated to a temperature suitable for a given permeation tube. The threshold levels of peak detection were established based on the analysis of the zero line. Chromatographic analysis of standards and air samples was carried out in identical operating conditions of the chromatographic system.

Determination of the fattening house microclimate. Thermal and humidity conditions, as well as dustiness, were controlled parallel with the chromatographic analysis in the fattening house and in its vicinity. The temperature and humidity of air were measured with a hytherograph (model RT811E, Technik, Warsaw, Poland), and the air flow was measured with an anemometer (model A-1200M1, OBRAiUP, Łódź, Poland). Dustiness was measured with the gravimetric method, in which air samples were taken with an individual aspirator (model 224-PCEX8, SKC, Dorset, England).

Statistic analysis. All the determination results were characterised by the number of samples taken (N), arithmetic mean (M), and standard deviation (SD). The results obtained were statistically analysed. Analysis of the influence of the place and time of the sampling on the concentration of the gaseous compounds determined in the air was carried out with the Student's t-test with statistic modules SAS v. 9.1 and Statistica v. 6.0.

RESULTS

The air chromatographic analysis carried out at the pig farm showed the presence of aldehydes, alcohols, aromatic and aliphatic hydrocarbons, amines, sulphurorganic and chloroorganic compounds (Tab. 1) among volatile organic compounds (VOCs). However, the level of organic gaseous pollutants was twice as high in the fattening house as in the atmospheric air ($p \leq 0.05$). The mean concentration of all VOCs, including the non-identified ones, exceeded 2,500 $\mu g/m^3$ with the highest level of hexanal and sulphurorganic compounds, i.e. methyl mercaptan and isopropyl mercaptan, as well as carbon disulfide. High concentrations were marked as 1 – propanol, 2 – butamine and trichloroethylene.

The mean concentration of all volatile compounds was 1,095.48 μg/m^3 (Tab. 1) in the atmospheric air in the vicinity of the farm. Aldehydes (pentanal and hexanal) prevailed in the determined pollutants, as well as 2-pentaamine and 2-methyl-1-propanol (Tab. 1), whereas among sulphurorganic compounds (Tab. 2) methyl mercaptan prevailed.

Buthyl mercaptan and methyl sulphide were not detected in the fattening house air, and 2-methylpentan and carbon disulfide were not detected in the air samples taken in the vicinity of farm, which could be suggested as the source of their formation.

Statistic analysis of the fattening house air and the atmospheric air showed differences in concentration only for methyl ethyl sulphide and isopropyl mercaptan (Tab. 1). The mean concentration of methyl ethyl sulphide was 25 times higher, and for isopropyl mercaptan it was 10 times higher in the fattening house air than in the atmospheric air. The differences were a highly statistically significant ($p \leq 0.01$).

The level of determined compounds depended not only on the place but also on the time (series) of the sampling (Tab. 2–5). The mean concentration of VOCs (including the non-identified ones) in the fattening house air samples was very variable and reached the maximum value (4,154.60 μg/m^3) in series I, whereas the minimum value (895.60 μg/m^3) was reached in series III of the study (Tab. 2). Statistical analysis showed a decrease in air pollution only between series II and III of the study.

In the indoor air, methane, 1-pentanol, ethyl benzene, hexanal, and xylene showed significant fluctuations (Tab. 2), as well as typically odorogenous compounds, i.e. methyl propyl sulphide and dipropyl sulphide, indoles, and phenols (Tab. 3). In the period of low temperatures in series I of the study methane and trichlorethylene reached high concentrations, respectively 172.54 μg/m^3 and 228.77 μg/m^3. A significant decrease in the concentration of methane and ethyl benzene ($p \leq 0.01$) (Tab. 2), as well as phenol ($p \leq 0.05$) (Tab. 3) was noticed together with an increase in air temperature. The opposite tendency was observed for 1-pentanol ($p \leq 0.01$), xylenes and hexanal ($p \leq 0.05$) (Tab. 4). Hexanal in series IV of the study reached a very high concentration of 108.31 μg/m^3, which was the highest in the whole study period.

The concentration of gaseous organic pollutants in the atmospheric air during the first three study series tended to fall (Tab. 4). In the final series IV, a distinct increase in the concentration of all volatile gaseous compounds (including the non-identified ones) was observed; however, it was not statistically proven. During that time, a significant increase in the concentration of the following compounds was noticed in the air: hexanal, 1-pentanol, and aromatic hydrocarbons, i.e. benzene, xylenes, and toluene (Tab. 4). The increased pollution concentration with sulphur compounds, especially with methyl ethyl sulphide, diethyl sulphide and dipropyl sulphide, was observed in the atmospheric air, as well as in the fattening house in the subsequent series. The differences were statistically important (Tab. 5).

Table 1. Mean concentration of VOCs in air samples taken (μg/m^3).

Compounds	Fattening house (N=16)		Vicinity of the farm (N=24)	
	M	SD	M	SD
Total (including unidentified)	2,515.40^a	1,883.58	1,095.48^a	471.64
Aldehydes				
Pentanal	3.22	1.15	58.10	47.77
Hexanal	103.81	197.41	64.20	114.24
Alcohols				
Ethanol	15.38	19.29	3.75	1.82
Propanol	60.53	69.48	18.75	20.42
Cyklobutanol	19.99	0.01	20.25	6.49
1-propanol	87.31	86.65	1.52	1.41
1-butanol	31.03	26.75	6.81	5.43
2-methyl-1-propanol	9.32	9.48	54.30	63.99
1-pentanol	36.71	33.49	45.79	46.71
Aliphatic hydrocarbons				
Metan	55.96	80.26	15.92	20.80
2-metylopentan	16.84	20.05	–	–
Methylocyclopentane	11.62	17.87	38.24	49.73
Aromatic hydrocarbons				
Benzen	18.74	14.66	15.15	21.66
Ethylobenzen	24.66	26.88	17.15	14.94
Xsylenes	31.81	14.77	35.95	22.52
Toluen	14.01	7.43	27.23	34.32
Amines				
2-buthanamine	73.99	67.79	10.91	1.08
2-pentanoamine	30.57	30.10	79.09	105.71
Sulphurorganic compounds				
Methyl mercaptan	813.69	210.34	108.16	189.37
Ethyl mercaptan	87.15	70.72	0.08	0.01
CS_2	220.65	9.34	–	–
Butyl mercaptan	–	–	0.64	0.43
Methyl ethyl sulfide	24.26^A	30.61	0.94^A	0.74
Diethyl sulfide	0.73	0.93	0.84	0.72
Methyl propyl sulfide	1.11	0.79	0.55	0.58
Dipropyl sulfide	10.78	15.00	11.66	15.85
COS	18.60	35.35	3.06	2.89
Methyl sulfide	–	–	1.58	0.55
Isopropyl mercaptan	103.07^A	6.11	11.01^A	3.99
Chloroorganic compounds				
Trichloroethylene	72.80	115.90	32.21	40.80
Other				
Indole	35.73	41.49	29.02	32.71
Phenol	14.48	10.66	41.24	41.03
3-caren	9.44	9.77	9.92	4.75

N = number of collected samples, M = arithmetic mean, SD = standard deviation, – = not found, $^{a, b, \ldots}$ – results marked with the same letters vary statistically in a significant manner for $p \leq 0.05$; $^{A, B, \ldots}$ – results marked with the same letters vary statistically in a significant manner for $p \leq 0.01$.

Table 2. Concentration of aldehydes, alcohols, aromatic and aliphatic hydrocarbons, and amines in the fattening house air during the study (μg/m³).

Compounds	Series							
	I		II		III		IV	
	N = 4		N = 4		N = 4		N = 4	
	M	SD	M	SD	M	SD	M	SD
Total (including unidentified)	4154.60	2623.08	2496.00^{a}	486.49	895.60^{a}	0.28	3493.95	1330.85
Aldehydes								
Pentanal	–	–	–	–	–	–	3.22	1.15
Hexanal	5.97^{a}	0.46	293.23	403.65	7.71^{b}	1.71	108.31^{ab}	20.54
Alcohols								
Ethanol	29.02	0.02	–	–	1.74	0.02	–	–
Propanol	–	–	1.49	0.01	–	–	90.06	66.53
Cyklobutanol	19.99	0.01	–	–	–	–	–	–
1-propanol	3.88	0.01	129.02	67.64	–	–	–	–
1-butanol	9.67	5.87	52.39	16.96	–	–	–	–
2-methyl-1-propanol	–	–	6.18	5.07	–	–	12.45	14.31
1-pentanol	16.77^{Ab}	0.57	26.41^{Ac}	1.22	3.23	0.01	83.70^{bc}	13.57
Aliphatic hydrocarbons								
Metan	172.54^{AB}	8.31	2.51^{AC}	0.04	5.98^{BC}	0.51	29.69	0.01
2-metylopentan	–	–	5.49	5.51	–	–	39.55	0.04
Methylocyclopentane	1.06	0.36	32.02	31.32	6.51	7.39	6.88	6.83
Aromatic hydrocarbons								
Benzen	23.68	12.00	20.49	21.95	5.37	0.03	–	
Ethylobenzen	31.79^{A}	0.42	5.26^{A}	2.14	1.91	0.09	71.96	0.23
Xsylenes	16.07^{ab}	4.10	47.73^{a}	8.41	31.64^{b}	1.01	–	–
Toluen	17.28	8.15	8.77	1.88	14.17	0.08	15.91	13.31
Amines								
2-buthanamine	73.92	66.15	142.65	0.02	–	–	5.45	0.01
2-pentanoamine	17.49	0.00	2.89	0.01	11.85	0.02	60.31	23.82

N = number of collected samples, M = arithmetic mean, SD = standard deviation, – = not found, $^{a, b...}$ = results marked with the same letters vary statistically in a significant manner for $p \leq 0.05$, $^{A, B...}$ = results marked with the same letters vary statistically in a significant manner for $p \leq 0.01$.

The study started in the winter months, when the atmospheric air temperature was 4.2ºC, and it finished in the summertime with a high air temperature of 29.4ºC (Tab. 6). A similar thermal distribution was observed in the piggery air. Dustiness increased in the indoor air, together with an increase in temperature and decrease in humidity and reached a high level of 6.67 mg/m³ in study series III.

DISCUSSION

The chemical constitution of the air in inventory rooms is very different from the constitution of the atmospheric air, since it contains much more carbon dioxide, ammonia, and hydrogen sulphide. The results of the study show that there are significant differences between the concentrations of identified air pollutants. In the fattening house the air was polluted mainly with alcohols (propanol), aldehydes, amines, and chloroorganic compounds (trichloroethylene). In the analysed air, sulphur compounds were also determined at a high level, where mercaptans, especially methyl mercaptan and ethyl mercaptan, i.e. compounds formed during metabolising sulphur amino acids in the pig's digestive system, reached the highest concentrations [25].

It is worth highlighting that in the fattening house the highest concentration was observed during the coldest season of the year, when in order to maintain thermal conditions the ventilation was decreased, which led to the significant accumulation of volatile organic compounds (VOCs) in the building. Accordingly, in the atmospheric air most of the determined VOCs reached the lowest level. In the period of low temperatures significantly lower atmospheric air pollution with sulphur compounds was observed. This was connected with the low microbiological activity of the investigated environment, since compounds containing sulphur are produced mainly by *Megasphaera* bacteria, which have an optimum growth temperature of 25–40ºC [25]. Only an increase in the atmospheric air temperature caused a significant rise in air pollution with sulphur com-

Table 3. The concentration of sulphurorganic and chloroorganic compounds in the fattening house air during the study (μg/m^3).

Compounds	Series							
	I		II		III		IV	
	N = 4		N = 4		N = 4		N = 4	
	M	SD	M	SD	M	SD	M	SD
Sulphurorganic compounds								
Methyl mercaptan	145.36	0.98	1.14	1.47	282.24	391.04	90.87	109.64
Ethyl mercaptan	37.14	0.09	137.16	0.32	–	–	–	–
CS_2	–	–	220.65	8.98	–	–	–	–
Butyl mercaptan	–	–	–	–	–	–	–	–
Methyl ethyl sulfide	22.06	14.56	–	–	1.68	0.20	49.05	47.08
Diethyl sulfide	0.16	0.07	0.29	0.09	–	–	1.52	1.15
Methyl propyl sulfide	0.46^a	0.12	1.43	0.60	0.15	0.10	1.92^a	0.30
Dipropyl sulfide	0.46^a	0.08	–	–	2.78^b	1.21	29.09^{ab}	10.57
COS	–	–	1.41	0.94	0.38	0.46	44.91	51.87
Methyl sulfide	–	–	–	–	–	–	–	–
Isopropyl mercaptan	–	–	103.07	6.11	–	–	–	–
Chloroorganic compounds								
Trichloroethylene	228.77	110.34	4.04	0.00	4.81	3.67	19.21	6.81
Other								
Indole	29.72	0.12	92.37^a	29.39	3.27^{ab}	1.83	14.55^b	2.30
Phenol	22.56^a	4.16	3.06^a	0.97	21.16	0.89	–	–
3-caren	0.59	0.15	15.12	10.96	15.80	0.67	–	–

N = number of collected samples, M = arithmetic mean, SD = standard deviation, – = not found, $^{a, b, \ldots}$ – results marked with the same letters vary statistically in a significant manner for $p \leq 0.05$.

pounds. Also, a noticeable increase in the concentration of aromatic hydrocarbons was observed in this period, which could be the result of intensive field work characteristic for this season.

Most VOCs determined in the animal breeding are produced during the decomposition of fresh droppings, as well as droppings lying under animals, urine and rotting feed. These compounds are formed mainly as a result of droppings' fermentation with the assistance of bacteria, genera *Streptococcus*, *Peptostreptococcus*, *Eubacterium*, *Lactobacillus*, *Escherichia*, *Clostridium*, *Propionibacterium*, *Bacteroides* and *Megasphaera*. The amount of released gases depends on their number and activity, as well as the availability of substrates, environment conditions, i.e. availability of oxygen, pH, faeces concentration and storage method [22]. In fresh droppings, there is little activity of decomposing bacteria; their number increases together with the age of the stored droppings. Therefore, the amount of volatile substances released from droppings also increases during their storing [13]. Moreover, the constitution of the pollutants formed is different [11]. Hobbs [10] identified more than 170 various volatile compounds in stored liquid manure. Their concentration was correlated with the intensity of odour. In other words, the vented air released from the buildings is not the only source of organic pollutants, including the odorogenous ones. Also, the air from the droppings' storage places is the source of organic pollutants. Therefore, very high concentrations of methyl mercaptan and 2-pentamine were determined in the air in the vicinity of the farm and around the dunging gutter.

Not only temperature but also dustiness and air flow influenced the level of air pollution with volatile gaseous compounds in the fattening house. A study carried out by Kai et al. [11] showed the presence of 50 various compounds, including alkanes, alcohols, aldehydes, ketones, acids, amines and heterocyclic nitrogen compounds, sulphides, mercaptans, aromatic compounds and furanes in the organic dust taken in the piggery. These compounds may be much more concentrated in dust particles than in a equivalent air volumes [1]. The release of gaseous pollutants coming from the bedding was increased by the intensified air flow determined at that time.

Most of the determined compounds are characterised by significant noxious odour. A study carried out by Radon *et al.* [15] showed that as many as 61% of those polled living in the neighbourhood of farms and their surroundings complained about the unpleasant smell and as many as 91% of those polled believed breeding farms to be the source of this smell. Publisched data prove that these compounds are harmful to the health of people with long term exposure to these vapours. In addition, people working in fattening houses may be exposed to these compounds at concentra-

Table 4. The concentration of aldehydes, alcohols, aromatic and aliphatic hydrocarbons, and amines in the air in the vicinity of the farm during the study (μg/m^3).

Compounds	Series							
	I		II		III		IV	
	N = 6		N = 6		N = 6		N = 6	
	M	SD	M	SD	M	SD	M	SD
Total (including unidentified)	1539.80	497.39	968.47	251.35	778.17	328.41	3689.23	872.98
Aldehydes								
Pentanal	–	–	–	–	–	–	58.10	47.77
Hexanal	5.92^{AB}	0.59	2.18^{A}	0.01	3.27^{B}	0.96	224.78	109.83
Alcohols								
Ethanol	5.62	0.00	3.64	0.02	1.98	0.02	–	–
Propanol	11.69	0.01	9.89	11.19	52.40	0.01	–	–
Cyklobutanol	19.20	2.58	21.29	10.74	–	–	–	–
1-propanol	1.52	1.41	–	–	–	–	–	–
1-butanol	4.65	0.26	17.83	0.01	3.91	0.01	4.92	1.12
2-methyl-1-propanol	161.52	2.33	7.68	0.23	0.94	0.44	77.36	6.63
1-pentanol	9.09^{A}	3.66	42.38	45.17	4.47	0.01	99.67^{A}	22.76
Aliphatic hydrocarbons								
Metan	50.29	2.30	2.32	0.17	6.12	0.20	4.94	0.22
2-metylopentan	–	–	–	–	–	–	–	–
Methylocyclopentane	2.29	0.63	57.04	71.51	20.74	0.09	54.74	50.89
Aromatic hydrocarbons								
Benzen	6.02^{A}	4.01	4.35^{B}	1.83	2.64^{C}	2.10	53.00^{ABC}	5.41
Ethylobenzen	34.12	6.52	2.27	0.39	2.39	0.47	24.91	1.24
Xsylenes	7.43^{AB}	0.28	27.78	22.19	36.34^{AC}	4.07	62.74^{BC}	5.95
Toluen	8.89^{a}	4.31	–	–	0.99^{b}	3.14	67.03^{ab}	33.32
Amines								
2-buthanamine	10.91	0.01	–	–	–	–	–	–
2-pentanoamine	4.34	0.02	–	–	–	–	153.83	0.03

N = number of collected samples, M = arithmetic mean, SD = standard deviation, – = not found, $^{a, b...}$ = results marked with the same letters vary statistically in a significant manner for p≤0.05, $^{A, B...}$ = results marked with the same letters vary statistically in a significant manner for p≤0.01.

tions much higher than the values estimated as threshold or toxic.

According to Schiffman [20], volatile organic compounds may irritate the eyes, throat and nose. VOCs may stimulate sensory nerves and cause neurochemical changes, as well as causing health effects based on cognitive and emotional factors, i.e. an attitude towards unpleasant smells or memory experience with similar smells. Long-term exposure to these compounds can decrease human immunity, with numerous potential effects. Health symptoms, such as irritation of eyes, nose and mouth, headache, diarrhoea, hoarseness, mouth ulceration, cough, pressure in the thoracic cavity, palpitations, shortened breath, stress, sleepiness, and mood changes are typical symptoms present in people living in the neighbourhood of breeding farms. The intensity of symptoms depends on the concentration of the air pollution [14]. Irritation caused by odours may also induce respiratory illness, including asthmatic changes [19], especially when the concentration of VOCs in the air exceeds 2.5 mg/m^3 [14]. High air pollution with VOCs of over 25 mg/m^3 may lead to more severe, i.e. neurotoxic and carcinogenic effects [13].

Almost half of the organic gaseous pollutants determined in the fattening house air are listed among the harmful chemical factors in the work environment; however only the concentration of methyl mercaptan exceeded the permissible concentration of 1 mg/m^3 [17]. None of the remaining compounds exceeded the level settled by the decree. However, it is uncertain if the concentrations of the determined pollutants were not hazardous to the health of animals and people working with them.

To date, there are no standards or recommendations in Poland that limit the occurrence of VOCs as a group of pollutants. Meanwhile, the Dutch Health Committee set the permissible maximum level of indoor air pollution for VOCs at a level of 0.2 mg/m^3 to the maximum level of

Table 5. Concentration of sulphurorganic and chloroorganic compounds in the air in the vicinity of the farm during the study (μg/m³).

Compounds	Series							
	I		II		III		IV	
	N = 6		N = 6		N = 6		N = 6	
	M	SD	M	SD	M	SD	M	SD
Sulphurorganic compounds								
Methyl mercaptan	0.03	0.01	–	–	251.97	231.59	10.39	6.20
Ethyl mercaptan	0.07	0.03	0.09	0.09	–	–	–	–
CS_2	–	–	–	–	–	–	–	–
Butyl mercaptan	–	–	–	–	0.15	0.09	0.89	0.08
Methyl ethyl sulfide	0.32^{A}	0.16	–	–	1.09	1.07	1.40^{A}	0.34
Diethyl sulfide	0.47^{a}	0.62	0.40	0.56	0.38^{b}	0.10	1.67^{ab}	0.38
Methyl propyl sulfide	0.04	0.77	0.14	0.86	0.34	0.35	1.06	0.60
Dipropyl sulfide	0.23^{AB}	0.09	–	–	2.28^{AC}	0.14	32.49^{BC}	5.06
COS	0.41	0.35	–	–	1.24	0.08	5.15	2.74
Methyl sulfide	1.58	0.55	–	–	–	–	–	–
Isopropyl mercaptan	–	–	11.01	3.99	–	–	–	–
Chloroorganic compounds								
Trichloroethylene	71.84	59.28	14.29	13.40	3.43	1.48	28.44	15.20
Other								
Indole	12.80	6.30	73.99^{ab}	27.05	14.11^{a}	18.61	9.78^{b}	8.10
Phenol	31.66	9.97	131.29	1.98	20.81	11.57	–	–
3-caren	6.22	2.59	14.46	3.49	8.27	0.78	–	–

N = number of collected samples, M = arithmetic mean, SD = standard deviation, – = not found, $^{a, b...}$ = results marked with the same letters vary statistically in a significant manner for $p \leq 0.05$, $^{A, B...}$ = results marked with the same letters vary statistically in a significant manner for $p \leq 0.01$.

Table 6. Mean* parameters of microclimatic conditions during the study.

Parameters	Fattening house				Vicinity of the farm			
	Series				Series			
	I	II	III	IV	I	II	III	IV
	N = 2	N = 2	N = 2	N = 2	N = 2	N = 2	N = 2	N = 2
Temperature (°C)	11.3	14.0	17.5	29.1	4.2	13.3	20.1	29.4
Air flow (m/s)	0.2	0.4	0.6	0.1	1.4	1.8	1.6	2.2
Humidity of air (%)	75.5	81.0	63.0	55.6	71.0	56.0	50.3	31.6
Dustiness (mg/m³)	0.83	2.50	6.67	5.00	1.94	–	0.83	4.17

* for 2 subsequent days

3.0 mg/m³. The recommended air threshold level for rooms where people are living is 0.2 mg/m³ [7]. In other words, the assessment of the gaseous constitution of air in the fattening house showed that the level of determined pollutants could have a negative impact on the health of people and animals, especially as in this type of facility not only chemical pollutants but also organic dusts and biological factors (bacteria, fungi, viruses, and their metabolites) are generated, whose negative influence on human health can be mutually increased [5, 23].

Comparison of the results of the atmospheric air samples taken from the vicinity of the farm with the valid standards also shows very high levels of air pollution in the vicinity of the farm. A mean concentration of the sum of mercaptans, phenol, xylene, 2-methyl-1-propanol, and toluene exceeded their basic values determined in the atmospheric air stated for the calendar year [18].

CONCLUSIONS

This air quality study showed that emissions released from pig farms locally impairs the air quality by the emission of volatile organic compounds, sulphur compounds, and dust. The type of individual odour components and

their concentration depend on the health of animals, feeding, and the type of putrefactive processes that take place in bedding. Skilful control of the level of the aforementioned factors, e.g. by the use of biological methods of air purification [3], accurate adherence to zoohygienic regimes and proper processing of manure may significantly decrease the formation and emission of odour into areas in the vicinity of a farm.

Acknowledgements

This study was supported by the Ministry of Scientific Research and Information Technology of Poland (Grant No. N311 015 32/145).

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