Chapter 9

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Evaluation of the Usefulness of Emission Rate Indexes in the Assessment of the Environmental Impact of Chicken Broiler Houses

1. Introduction

The development of poultry production is linked to development of existing and construction of new farms rearing of broiler chickens. The main task posed to these objects is to provide in a relatively short period of time large quantities of possible low-cost, high-quality raw material. In relation to food safety, animal welfare and environmental protection law regulations, there is emphasis on the use of farming technologies that meet the requirements of best available techniques (BAT).

BAT requirements for breeding and poultry farming represents the Reference Document on Best Available Techniques for Intensive Rearing of Poultry and Pigs (Reference Document 2005) described with the abbreviation ILF BREF. Under the existing rules (Directive 2010/75/UE) BAT means the most effective and advanced stage in the development of activities and their methods of operation which indicates the practical suitability of particular techniques for providing the basis for emission limit values and other permit conditions designed to prevent and, where that is not practicable, to reduce emissions and the impact on the environment as a whole.

The obligations associated with the requirements of best available techniques apply only to the largest farms, with the density exceeding 40 000 places for poultry (farms IPPC – abbreviation from the title of Directive Integrated Pollution Prevention and Control). Exploitation of these objects requires special arrangements in the form of integrated permits, which inter alia, indicate the levels of pollutant emissions.

During construction or expansion of the farm there should be taken into consideration obligations related to the assessment of the farms environmental impact. Regulation on investments that may significantly affect the environment

(J.Law. 2010.213.1397), in the § 2 section 1 point 51, indicates that the procedure of environmental impact assessment should be mandatory for farms holding at least 210 animal units (AU), which corresponds to 52500 broiler standpoints. However, in the case of farms with the density above 40 AU located near buildings, recreational areas, or areas covered by forms of nature conservation or farms with the livestock exceeding 60 AU located in other areas, the above regulation in the § 3 section 1 points 102 and 103, indicates that these are projects that could potentially have significant effects on the environment, and therefore the competent authority may impose obligation to prepare an environmental impact report. European Union regulations in this area are less restrictive (Directive 85/337/EEC) because indicate that installations for the intensive rearing of poultry with more than: 85 000 places for broilers or 60 000 places for hens should be subjected to environmental impact assessment.

As the most significant impact of poultry rearing farms on the environment there should be listed: gas and odors emissions into the air, production of large quantities of deep litter manure or manure as well as waste generation. Air quality around poultry farms is a key element associated with their operation. In the air around livestock buildings there might be detected numerous odorants: hydrogen sulfide, ammonia, thiols, sulfides and aliphatic amines, heterocyclic organic compounds containing sulfur and nitrogen, aliphatic alcohols, phenols, ketones, aldehydes, aliphatic acids and esters (Kośmider at all, 2002). As the primary air pollution there are listed: dust, ammonia, methane and nitrous oxide (Reference Document 2005).

In this paper the indexes of air pollutant emissions (gases and dust) from livestock buildings of chickens broiler were reviewed. As the primary pollutant emissions, the substances indicated in the reference document ILF BREF were adopted. There was made revision of the legal status of the permissible concentrations of substances in the air. There were also made calculations of pollutants imission around theoretical poultry houses, with the livestock number that qualify farm as the IPPC installation and according to Council Directive 85/337/EEC as installation that should be subjected to environmental impact study. Calculations of substances concentration were performed in accordance with the requirements of the methodology specified in the applicable provisions of law (Dz.U.2010.16.87). The concentration of each substance were evaluated for the two ventilation systems of wall fans: horizontal and vertical direction of exhaust gases outflow. Variants of calculations were also indicators of emissions, the calculation was performed for both the minimum and maximum emission indexes set out in ILF BREF.

In the calculations of the emission levels, method based on protein balancing and pollution indicators developed by Institute for Building, Mechanization and Electrification in Agriculture (IBMER) were also taken into consideration. Both methods are recommended to determine the emissions for the development of reports for the National Pollutant Release and Transfer Register, the so-called E-PRTR reports (abbreviation from The European Pollutant Release and Transfer

Register). PRTR reporting obligations concerns IPPC farms and results from the provisions of Regulation (EC) no 166/2006 of the European Parliament and the Council of 18 January 2006 concerning the establishment of a European Pollutant Release and Transfer Register and amending Council Directive 91/689/EEC and 96/61/WE.

2. Research conditions

In order to determine the differences between emission factors the balance of annual emissions and 1-hour emissions of pollutants were made. The basis for calculations was the theoretical farm of chicken broilers, which included two houses (K1 and K2) each for 40 000 birds. It was assumed that each object is a single nave hall with dimensions of 19 x 120 m, equipped with mechanical ventilation: 6 wall fans ø 1.4 m, h = 2.5 m and 11 roof fans ø 0.63 m. Roof fans are mounted axially in the exhaust chimneys. The outlets of chimneys are situated over a ridge of roofs at a height h = 6 m above ground level and they are not finished with covers. It was also assumed that the number of production cycles per year is 6, the length of a single cycle is 42 days, a single bird eats 3,8 kg of feed during the rearing cycle. Surrounding of the chicken houses are cultivated fields, which are characterized by the coefficient of aerodynamic roughness of the terrain z_0 = 0,035 m. Because wall fans do not operate in autumn and winter period, it was assumed that 65% of emissions are derived through the roof ventilators, and 35% by wall fans. Assessment of concentrations of individual substances was performed for the two ventilation systems: horizontal and vertical exhaust of wall fans. On the basis of 1-hour and annual emission the concentrations of substances on the ground level were calculated. The calculations were carried out in a XY orthogonal (1000 x 1000 m) net of receptors arranged in 20 x 20 m squares.

Because of above listed conditions in the calculations there were considered the following variants:

- variant 1 - emissions calculated on the basis of minimum indexes from ILF BREF, wall fans – horizontal outflow,
- variant 2 - emissions calculated on the basis of minimum indexes from ILF BREF, wall fans – vertical outflow,
- variant 3 - emissions calculated on the basis of maximum indexes from ILF BREF, wall fans – horizontal outflow,
- variant 4 - emissions calculated on the basis of maximum indexes from ILF BREF, wall fans – vertical outflow,
- variant 5 - emissions calculated on the basis of IBMER indexes, wall fans – horizontal outflow,
- variant 6 - emissions calculated on the basis of of IBMER indexes, wall fans – vertical outflow,
- variant 7 - emissions calculated on the basis of protein balance, wall fans – horizontal outflow,
- variant 8 - emissions calculated on the basis of protein balance, wall fans – vertical outflow.

The direction of outflow air from the roof fans, in each case is vertical. All the fans were marked by successive symbols from E-1 to E-34. K1 roof fans are emitters of the symbols of E-1 to E-11, wall fans: E-12 to E-17. Roof fans of K2 broiler house are emitters E-18 to E-28, and the wall fans: E-29 to E-34. Data of individual emitters are summarized in Table 1.

Table 1

Parameters of point emitters E-1 – E-34

Symbol	Emitor's hight [m]	Diameter [m]	Outflow velocity [m·s^{-1}]	Outflow air elevation [m]*	Coordinates [m]	
					X	Y
E-1	6	0.63	5	7.2	480.5	550.0
E-2	6	0.63	5	7.2	480.5	540.0
E-3	6	0.63	5	7.2	480.5	530.0
E-4	6	0.63	5	7.2	480.5	520.0
E-5	6	0.63	5	7.2	480.5	510.0
E-6	6	0.63	5	7.2	480.5	500.0
E-7	6	0.63	5	7.2	480.5	490.0
E-8	6	0.63	5	7.2	480.5	480.0
E-9	6	0.63	5	7.2	480.5	470.0
E-10	6	0.63	5	7.2	480.5	460.0
E-11	6	0.63	5	7.2	480.5	450.0
E-12	2.5	1.40	4	0.0 / 18.5	473.0	560.0
E-13	2.5	1.40	4	0.0 / 18.5	475.0	560.0
E-14	2.5	1.40	4	0.0 / 18.5	477.0	560.0
E-15	2.5	1.40	4	0.0 / 18.5	484.0	560.0
E-16	2.5	1.40	4	0.0 / 18.5	486.0	560.0
E-17	2.5	1.40	4	0.0 / 18.5	488.0	560.0
E-18	6	0.63	5	7.2	519.5	550.0
E-19	6	0.63	5	7.2	519.5	540.0
E-20	6	0.63	5	7.2	519.5	530.0
E-21	6	0.63	5	7.2	519.5	520.0
E-22	6	0.63	5	7.2	519.5	510.0
E-23	6	0.63	5	7.2	519.5	500.0
E-24	6	0.63	5	7.2	519.5	490.0
E-25	6	0.63	5	7.2	519.5	480.0
E-26	6	0.63	5	7.2	519.5	470.0
E-27	6	0.63	5	7.2	519.5	460.0
E-28	6	0.63	5	7.2	519.5	450.0
E-29	2.5	1.40	4	0.0 / 18.5	512.0	560.0
E-30	2.5	1.40	4	0.0 / 18.5	514.0	560.0
E-31	2.5	1.40	4	0.0 / 18.5	516.0	560.0
E-32	2.5	1.40	4	0.0 / 18.5	523.0	560.0
E-33	2.5	1.40	4	0.0 / 18.5	525.0	560.0
E-34	2.5	1.40	4	0.0 / 18.5	527.0	560.0

It was assumed that the exhaust air temperature is 20ºC, and its specific heat is 1.3 $KJ \cdot m^{-3} \cdot K^{-1}$.

For the calculation of emissions level, the emission factors given in the ILF BREF (Table 2) and IBMER indicators (Table 3) recommended for use in the calculation of emissions in E-PRTR reports, given in the PRTR Methodology Guide (Jagodzińska, Marzysz 2009), were used.

Table 2

Emission factors from broiler houses (Reference Document 2005)

N.	Substance	Emission factor		Calculated factor
		min.	max	mean
		$[kg \cdot (bird \cdot year)^{-1}]$		
1	ammonia NH_3	0.005	0.315	0.160
2	methane CH_4	0.004	0.006	0.005
3	nitrous oxide N_2O	0.009	0.024	0.017
4	dust (inspirable)	0.119	0.182	0.016
5	dust (respirable)	0.014	0.018	0.151

In order to calculate emissions based on the balance of protein, the following formulas were used (Jagodzińska, Marzysz 2009):

$$E_{aNH_3} = [(Z_p \cdot B_{p\%} \cdot N_{B\%} \cdot k) - (P_o \cdot N_{O\%})] \cdot X \cdot d \ \ [kg \cdot year^{-1}]$$

$$E_{aCH_4} = 0{,}26 \cdot E_{aNH_3} \ [kg \cdot year^{-1}]$$

$$E_{N_2O} = 0{,}11 \cdot E_{aNH_3} \ [kg \cdot year^{-1}]$$

dust – method is not applicable

E_{aNH3} total (annual) emission of ammonia released into the air,
E_{aCH4} total (annual) emission of methane released into the air,
E_{aN2O} total (annual) emission of nitrous oxide released into the air,
Z_p amount of feed given to animals $[kg \cdot year^{-1}]$ (3.8 $kg \cdot (bird \cdot cycle)^{-1}$),
$B_{p\%}$ average protein content in the feed (between 13 – 24 %), generally 20%
$N_{B\%}$ the percentage of nitrogen content in the protein, it is assumed that it is 16% (the value used in calculation is 0.16) [–],
k feed conversion ratio, the share of nitrogen removed from the body in the total nitrogen in the feed [–] (broilers, k = 0,68)
P_o annual amount of manure $[kg \cdot year^{-1}]$ (1,9 $kg \cdot (bird \cdot cycle)^{-1}$),
$N_{O\%}$ the percentage content of nitrogen in fresh manure [–] ($N_{O\%}$ = 0,0326),
X percentage of the total NH_3 emission in the total nitrogen emissions from livestock buildings [–],
d conversion factor of nitrogen to ammonia, d = 1,22

Table 3

IBMER emission factors from broiler houses (Jagodzińska, Marzysz 2009)

N.	Substance	Day of cycle	Emission factor	
			[kg·(h·bird)$^{-1}$]	[kg·(bird·cycle phase)$^{-1}$]
1	ammonia NH_3	9	0.00000183	0.00039528
2		7	0.00000370	0.00062160
3		7	0.00000615	0.00103320
4		8	0.00000860	0.00165120
5		11	0.00001090	0.00287760
6		sum:		0.00657888
7		calculated factor* [kg·(bird·year)$^{-1}$]		0.0395
8	methane CH_4	9	0,00000045	0,00009720
9		7	0,00000092	0,00015456
10		7	0,00000150	0,00025200
11		8	0,00000220	0,00042240
12		11	0,00000355	0,00093720
13		sum:		0,00186336
14		calculated factor* [kg·(bird·year)$^{-1}$]		0,0112
15	nitrous oxide N_2O	9	0.000000160	0.00003456
16		7	0.000000328	0.00005502
17		7	0.000000540	0.00009072
18		8	0.000000825	0.00015840
19		11	0.000001375	0.00036300
20		sum:		0.0007017
21		calculated factor* [kg·(bird·year)$^{-1}$]		0.0042
22	dust PM10	9	0.00000103	0.00022248
23		7	0.00000239	0.00040152
24		7	0.00000432	0.00072576
25		8	0.00000704	0.00135168
26		11	0.00001083	0.00285912
27		sum:		0.00556056
28		calculated factor* [kg·(bird·year)$^{-1}$]		0.0334

* 6 production cycles per year was assumed

The concentration of a substance in the points on the ground level was calculated in accordance with the Pasquille equation indicated in the applicable law regulation (J.Law.2010.16.87):

$$S_{xy} = \frac{E_g}{\pi \cdot \bar{u} \cdot \sigma_y \cdot \sigma_z} \exp\left(-\frac{y^2}{2\sigma_y^2}\right) \exp\left(-\frac{H^2}{2\sigma_z^2}\right) \cdot 1000 \; [\mu g \cdot m^{-3}]$$

S_{xy} – substance concentration in the point with coordinates *x*, *y*, *z*, [$\mu g \cdot m^{-3}$],
E_g – maximum emission of gaseous substance [$mg \cdot s^{-1}$],
u – average wind velocity [$m \cdot s^{-1}$],
σ_y – horizontal atmospheric diffusion rate [m],
σ_z – vertical atmospheric diffusion rate [m],
y – component of the distance between the emitter and the calculated point [m],
H – effective height of the emitter [m],
exp – exponential function.

For the dispersion assessment of air pollutants as well as for the graphic results presentation OPERAT FB software, version 5.0.1., attested by the Environmental Protection Institute in Warsaw, under n. BA/147/96, was used. Weather conditions were adopted for the central Poland. The wind rose from meteorological station in Poznan was used (Figure 1).

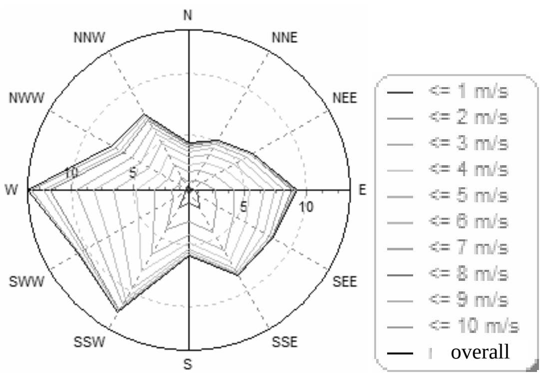

Fig. 1. Annual wind rose – meteorological station in Poznań

The calculations of the distribution of ammonia maximum concentrations (1 hour and 1 year) in the air considering the statistics of meteorological conditions were carried out in order to check whether the pollutant concentration on the ground level meets the following demand:

$$S_{mm} < D_1$$

S_{mm} - the highest maximum concentration in the air [$\mu g \cdot m^{-3}$],
D_1 – limit value of substance or admissible 1-hour concentration [$\mu g \cdot m^{-3}$].

The reference values or admissible concentrations of substances in the air are not violated if the exceeding frequency of admissible 1-hour concentrations (D_1), does not exceed 0.274% of time per year for sulfur dioxide and 0.2% - for other substances (J.Law.2010.16.87).

3. Results

The annual and hourly emission calculated on the basis of indexes presented in the table 2 and 3 as well as on the ground of protein balance method is presented in table 4.

Table 4

Emission from chicken broiler houses with a total broiler livestock of 80 000, calculated on the basis of analyzed emission indexes

N.	Substance	$kg{\cdot}h^{-1}$			$Mg{\cdot}year^{-1}$		
1	ILF BREF indexes						
		min	mean	max	min	mean	max
2	ammonia NH_3	0.0661	2.1164	4.1667	0.400	12.800	25.200
3	methane CH_4	0.0529	0.0661	0.0794	0.320	0.400	0.480
4	nitrogen oxide N_2O	0.1190	0.2183	0.3175	0.720	1.320	1.920
5	dust PM10	0.1852	0.2116	0.2381	1.120	1.280	1.440
6	IBMER indexes						
7	ammonia NH_3	0.8720			3.158		
8	methane CH_4	0.2840			0.894		
9	nitrogen oxide N_2O	0.1100			0.337		
10	dust PM10	0.8664			2.589		
11	balance of protein						
12	ammonia NH_3	0.4018			2.430		
13	methane CH_4	0.1045			0.632		
14	nitrogen oxide N_2O	0.0442			0.267		
15	dust PM10	-			-		

The emission levels calculated on the basis of the analyzed indexes (Table 4) indicate a substantial variation of the results for annual emissions of ammonia, (24.800 Mg), methane (0.574 Mg), nitrous oxide (1.653 Mg) and dust PM10 (1,469 Mg). Depending on calculation method, the amount of annual pollutants load might respectively differ by 6300% (NH_3), 279% (CH_4), 719% (N_2O) and 231% (PM10).

The maximum hourly emission results dispersion is in the case of ammonia 4.1006 $kg{\cdot}h^{-1}$, methane 0.2311 $kg{\cdot}h^{-1}$, nitrogen oxide 0.2733 $kg{\cdot}h^{-1}$, dust PM10 0.6812 $kg{\cdot}h^{-1}$. The level of emission, in dependence on calculation method may vary with 6303% (NH_3), 536% (CH_4), 718% (N_2O) and 468% (PM10).

Because of the fact that among the analyzed substances (Table 4), the law define reference values only for ammonia and dust PM10, based on the set of emission factors, the 1-hour and annual concentrations of these pollutants were calculated (Table 5).

Table 5

Maximum 1-hour and annual concentrations of ammonia and dust PM10

N.	Variant	Substance	Parameter	Value	X	Y
1	1	NH_3	max. 1-hour concentration [μg·m^{-3}]	171.98	540	560
2			average annual concentration [μg·m^{-3}]	4.86	500	560
3			exceeding frequency of D1= 400 μg·m^{-3}, [%]	0.00	-	-
4		PM10	max. 1-hour concentration [μg·m^{-3}]	240.78	460	560
5			average annual concentration [μg·m^{-3}]	6.81	500	560
6			exceeding frequency of D1= 280 μg·m^{-3}, [%]	0.00	-	-
7	2	NH_3	max. 1-hour concentration [μg·m^{-3}]	8.57	460	360
8			average annual concentration [μg·m^{-3}]	0.88	540	560
9			exceeding frequency of D1= 400 μg·m^{-3}, [%]	0.00	-	-
10		PM10	max. 1-hour concentration [μg·m^{-3}]	11.99	460	360
11			average annual concentration [μg·m^{-3}]	1.23	540	560
12			exceeding frequency of D1= 280 μg·m^{-3}, [%]	0.00	-	-
13	3	NH_3	max. 1-hour concentration [μg·m^{-3}]	**10834.92**	460	560
14			average annual concentration [μg·m^{-3}]	**306.35**	500	560
15			exceeding frequency of D1= 400 μg·m^{-3}, [%]	**21.75**	500	560
16		PM10	max. 1-hour concentration [μg·m^{-3}]	**309.57**	460	560
17			average annual concentration [μg·m^{-3}]	8.75	500	560
18			exceeding frequency of D1= 280 μg·m^{-3}, [%]	0.09	460	560
19	4	NH_3	max. 1-hour concentration [μg·m^{-3}]	**539.93**	460	360
21			average annual concentration [μg·m^{-3}]	**55.12**	540	560
22			exceeding frequency of D1= 400 μg·m^{-3}, [%]	**2.18**	540	560
23		PM10	max. 1-hour concentration [μg·m^{-3}]	15.43	540	360
24			average annual concentration [μg·m^{-3}]	1.58	540	560
25			exceeding frequency of D1= 280 μg·m^{-3}, [%]	0.00	-	-
26	5	NH_3	max. 1-hour concentration [μg·m^{-3}]	**2267.53**	460	560
27			average annual concentration [μg·m^{-3}]	38.39	500	560
28			exceeding frequency of D1= 400 μg·m^{-3}, [%]	**2.07**	500	560
29		PM10	max. 1-hour concentration [μg·m^{-3}]	**1126.48**	460	560
30			average annual concentration [μg·m^{-3}]	15.74	500	560
31			exceeding frequency of D1= 280 μg·m^{-3}, [%]	**1.00**	500	560

Table 5 continued

N.	Variant	Substance	Parameter	Value	X	Y
32	6	NH_3	max. 1-hour concentration [μg·m^{-3}]	243.11	480	560
33			average annual concentration [μg·m^{-3}]	4.25	500	560
34			exceeding frequency of D1= 400 μg·m^{-3}, [%]	0.00	-	-
35		PM10	max. 1-hour concentration [μg·m^{-3}]	**489.37**	480	560
36			average annual concentration [μg·m^{-3}]	10.37	500	560
37			exceeding frequency of D1= 280 μg·m^{-3}, [%]	0.08	480	560
38	7	NH_3	max. 1-hour concentration [μg·m^{-3}]	**1044.80**	460	560
39			average annual concentration [μg·m^{-3}]	29.54	500	560
40			exceeding frequency of D1= 400 μg·m^{-3}, [%]	**0.90**	500	560
44	8	NH_3	max. 1-hour concentration [μg·m^{-3}]	52.06	460	360
45			average annual concentration [μg·m^{-3}]	5.32	540	560
46			exceeding frequency of D1= 280 μg·m^{-3}, [%]	0.00	-	-

Values that exceed reference (admissible) values are in bold

Differences in the calculated emissions are causing substantial differences in the calculated concentrations at ground level (Table 5). In the case of variants that consider horizontal outflow of the wall fans, the difference between maximum 1-hour and annual concentrations was, respectively:

- ammonia: 10662.94 μg·m^{-3} and 301.49 μg·m^{-3} (difference between concentrations from variant 3 and 1),
- dust PM10: 885.70 μg·m^{-3} i 8.93 μg·m^{-3} (difference between concentrations from variant 5 and 1).

The isolines of ammonia concentration for the variant 1 and 3, in which extreme ammonia concentrations were noted are presented in Figure 2.

In the case of variants that consider vertical outflow of the wall fans, the difference between maximum 1-hour and annual concentrations was, respectively:

- ammonia: 531.36 μg·m^{-3} and 54.24 μg·m^{-3} (difference between concentrations from variant 4 and 2),
- dust PM10: 477.38 μg·m^{-3} i 9.14 μg·m^{-3} (difference between concentrations from variant 6 and 2).

The isolines of ammonia concentration for the variant 2 and 4, in which extreme ammonia concentrations were noted are presented in Figure 3.

The large range of differences in calculated ammonia concentrations is a result of wide range of emission indexes presented in ILF BREF. Differences that concern dust PM10 concentrations result from disparities between IBMER index and minimal index by ILF BREF. Above indicated differences of 1-hour concentrations exceed admissible reference value for ammonia (400 μg·m^{-3}) and dust PM10 (280 μg·m^{-3}). Similarly, in case of annual concentrations they exceed admissible reference values for ammonia (50 μg·m^{-3}) and dust PM10 (40 μg·m^{-3}).

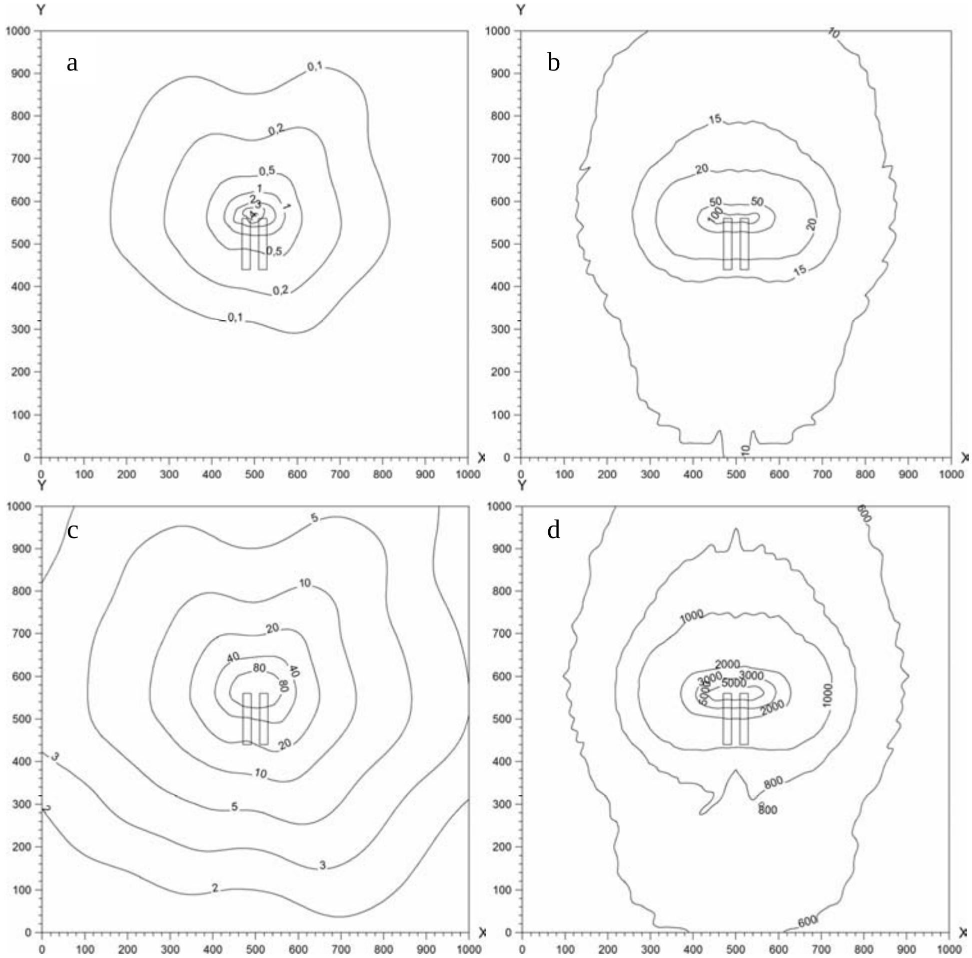

Fig. 2. Ammonia concentration isolines [μg·m^{-3}] around chicken broiler houses with horizontal gas outflow from wall fans , variant 1 (a – annual concentrations, b – maximum concentrations), variant 3 (c – annual concentrations, d – maximum concentrations)

A substantial effect on the distribution of concentration isolines also exert direction of outflow gases from wall fans. In each analyzed case, when comparing variants with the emission calculated on the basis of the same indexes, the calculated maximum (1-hour) concentrations of ammonia and dust PM10 were higher for the broiler houses with wall fans with horizontal direction of outflow gas than in buildings with wall fans with vertical outflow. Differences in dispersion of pollutants for each fan outlet systems illustrate isolines of 1-hour maximum concentrations (Figures 2b, 2d, 3b, 3d). Isolines of annual concentration, although to a lesser extent, also reflect a greater accumulation of pollutants following the horizontal direction of wall fans exhaust (Figures 2a, 2c, 3a, 3c). The horizontal exhaust of gases from livestock houses promotes forming, close to the buildings, the areas of temporary high concentration of pollutants (Figures 2b, 2d). It is result of the close distance of gas stream to the ground which cause ineffective dispersion of substances in the atmosphere. The horizontal exhaust of gases is also favorable for odor nuisances occurring (Wojewódzki 2009).

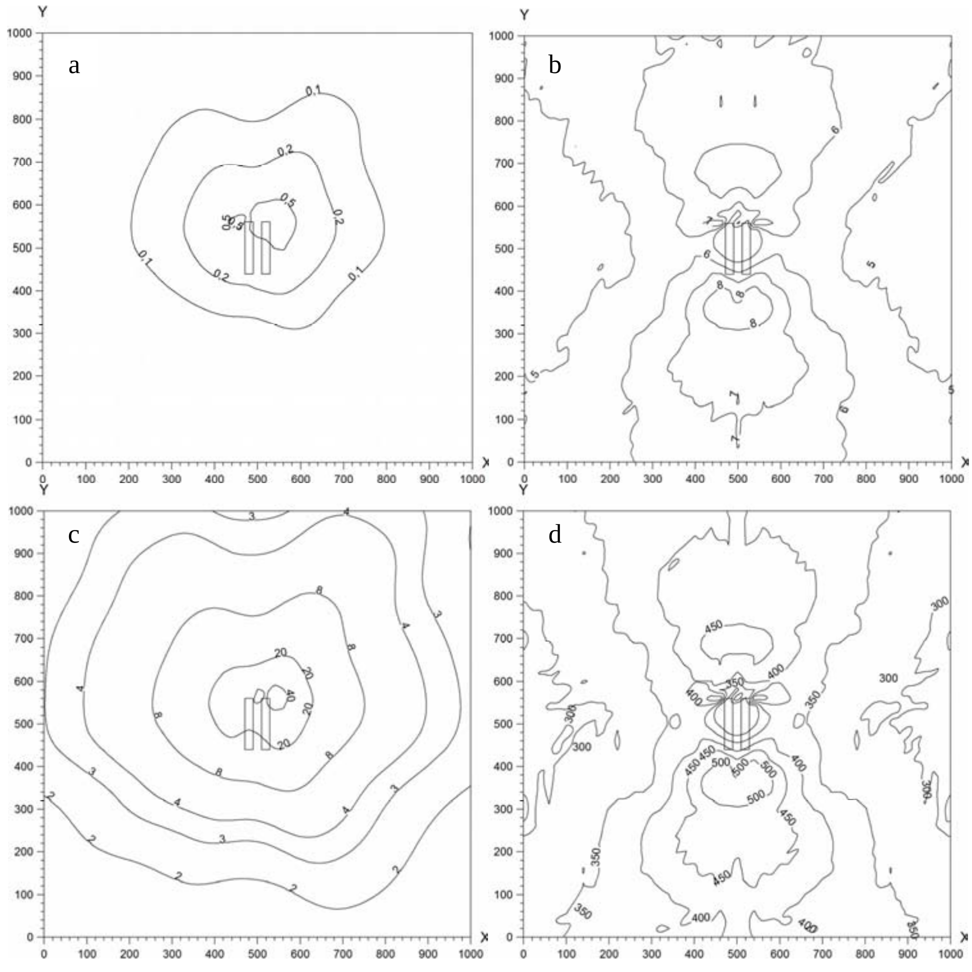

Fig. 3. Ammonia concentration isolines [$\mu g \cdot m^{-3}$] around chicken broiler houses with vertical gas outflow from wall fans , variant 2 (a – annual concentrations, b – maximum concentrations), variant 4 (c – annual concentrations, d – maximum concentrations)

The highest 1-hour and annual concentrations of ammonia were noted in variant 3 which concerns horizontal gas outflow from wall fans and maximum emission indexes by ILF BREF (Table 5, Figure 2c, 2d). The highest 1-hour and annual concentrations of dust PM10 were stated in variant 5 that concerns application of indexes given by IBMER. The violations of admissible concentrations, in above mentioned variants, occurred with the frequency: 21,75% and 1% time per year, respectively. The lowest concentrations of ammonia and dust PM10 were noted in case of broiler houses equipped with wall fans with vertical exhaust. The lowest 1-hour and average-annual concentrations were found in variant 2.

The use of minimum emission indexes by ILF BREF (variant 1 and 2) effects in determining the lowest emission (Table 4) and the lowest concentrations at the ground level (Table 5). Regardless of wall fans exhaust direction there are no violations of admissible reference 1-hour and average annual concentration values.

In case of use maximum emission indexes by ILF BREF (variant 3 and 4) there is noted high concentration of ammonia which exceed reference values: maximum 1-hour as well as average annual concentration. The horizontal direction of outflow gas from wall fans induces exceed of ammonia 1-hour concentration which appears by ca 80 days per year and vertical gas exhaust is the reason of exceeding ammonia 1-hour admissible concentration by ca 8 days (Fig. 4). The highest concentration of dust PM10, in case of vertical exhaust, is below admissible level.

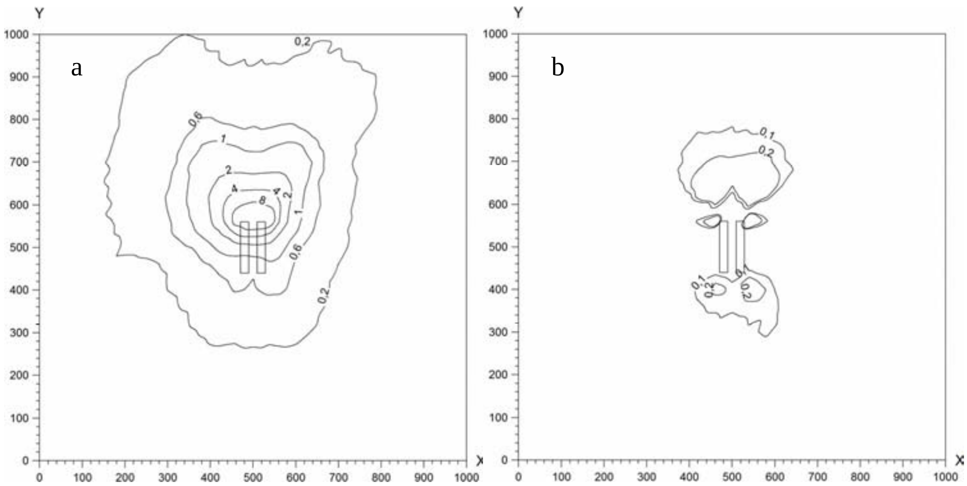

Fig. 4. Isolines of exceeding frequency [%] of ammonia admissible 1-hour concentration 400 μg·m^{-3}, limit value: 0.2% (a – variant 3, b – variant 4)

4. Summary

The major fault of emission indexes by ILF BREF and method of protein balance is possibility of calculation only annual emission. Calculated indexes of 1-hour emission result only from dividing annual emission by the number of installation operating hours which is the reason that 1-hour concentrations do not fully reflect impact of the broiler houses on the air quality. Moreover, calculation methodology indicated by applicable law regulation (J.Law.2010.16.87), that is used for assessment of pollutants concentration in the air, requires to determine the maximum 1-hour index of emission.

The 1-hour emission indexes calculated on the basis of maximum indexes by ILF BREF might lead to overestimating of 1-hour concentrations. Inversely, the 1-hour indexes calculated on the ground of minimum ILF BREF indexes and method of protein balance are probably underestimated and so that the assessment of exceeding of admissible values could be incorrect.

The above-described disadvantages are devoid IBMER indicators that take into account the increasing emissions of pollutants in successive stages of rearing broilers. In order to assess the maximum 1-hour concentrations it is possible to use the maximum 1-hour emission rates determined for the final phase of rearing. These indexes are not obtained by dividing the average annual emissions by the number of installation operating hours.

Because IBMER indexes are in the range, which describes reference document ILF BREF, as well as allow for an assessment of 1-hour concentrations of pollutants which is correlated with the phase of broiler rearing and is not a result of averaging annual emission it should be defined that their application for predicting the environmental impact of broilers houses is the most appropriate among analyzed emission indexes.

References

Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control).

Directive 85/337/EEC of the Council of 27 June 1985 on the assessment of the effects of certain public and private projects on the environment.

Jagodzińska A, Marzysz M., 2009. Poradnik Metodyczny w Zakresie PRTR. Główny Inspektorat Ochrony Środowiska w Warszawie.

Kośmider J., Mazur-Chrzanowska B., Wyszyński B. 2002. Odory, PWN, Warszawa, pp. 180.

Reference Document on Best Available Techniques for Intensive Rearing of Poultry and Pigs. 2005. Ministry of Environment, Warszawa.

Regulation (EC) no 166/2006 of The European Parliament and of The Council of 18 January 2006 concerning the establishment of a European Pollutant Release and Transfer Register and amending Council Directives 91/689/EEC and 96/61/EC.

Rozporządzenie Ministra Środowiska z dnia 9 listopada 2010 r. w sprawie przedsięwzięć mogących znacząco oddziaływać na środowisko (J.Law.2010.213.1397).

Rozporządzenie Ministra Środowiska z dnia 26 stycznia 2010 r. w sprawie wartości odniesienia dla niektórych substancji w powietrzu (J.Law.2010.16.87).

Wojewódzki P., 2009. Emisja zanieczyszczeń do powietrza z fermy intensywnego chowu brojlerów kurzych. Ekologia i Technika, vol. XVII, nr 5, 228-234.

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