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Environmental emissions from broiler houses in Bursa, Turkey

Ilker Kilic[a] and Erkan Yaslioglu[a]

a Uludag University, Agriculture Faculty, Department of Biosystems Engineering, Campus of Gorukle, 16059, Bursa, Turkey. Email: ikilic@uludag.edu.tr

Introduction

Poultry production systems in confined animal feeding operations contribute the largest portion of pollutant gas emissions recorded in Europe and USA (EPA, 2005). Broiler farms constitute 54% of the poultry production systems in the gas emission inventory and 14% of animal agriculture in USA (EPA, 2005). Modern broiler production systems have high-density housing to supply increasing market demands. High-density housing increases pollutant gas concentrations and emissions from broiler farms. The pollutant gas generation rates in broiler farms vary with and outdoor temperature; airflow rate; air velocity; time of day; bird species, activity and behaviour; number of birds; body weight; type of housing; manure handling system; manure pH, temperature, and surface area; litter material and condition; feed type and management system (Blanes-Vidal et al. 2007, Arogo et al. 2006).

Material and Methods

This study was conducted on three broiler houses (H1, H2 and H3) in Bursa, Turkey. During this study, approximately 12 000 birds were housed in H1 and H2. H3 held approximately 6 000 birds. All of the monitored houses used mechanical ventilation systems and had evaporative cooling-pad systems. In this study, pollutant gases concentrations, temperature, relative humidity, and air velocity were continuously monitored for four consecutive days in all houses. A multi-function T and RH meter with a hot-wire probe (Model 350 XL-454, Testo, Germany) was used to measure environmental conditions such as temperature, relative humidity. The pollutant gases concentrations were measured using portable multiple gas detectors with electro-chemical sensors (Ibrid MX6, Industrial Scientific, Oakland, PA, USA). For exhaust gas concentrations and T and RH measurements, all instruments were located front of ventilation fans in monitored house. The pollutant gas emission rates (ER) were calculated as the mass of gas emitted from the broiler house per unit time, using the following relationship described by Hinz and Linke (1998).

ER: $(C_i-C_a).Q$

where ER is the emission rate (g/(h house)),C_i is the gas concentration (ppm),C_a is the ambient gas concentration (ppm), and Q is the airflow rate (m^3/h house).

The data obtained for all variables of interest during the study period were analyzed using JMP 7.0 statistical software.

Results and Discussion

Pollutant Gas Concentrations and Emissions: The concentrations of pollutant gas in monitored broiler houses ranged from 2 to 93 for NH_3, from 5 to 59 ppb for H_2S, from 0.38 to 21 ppm for CH_4 and from 500 to 9518 ppm for CO_2 during all study period. In Figure 1, pollutant gas concentrations and emissions obtained from this study were given according to winter and summer seasons (Figure 1).

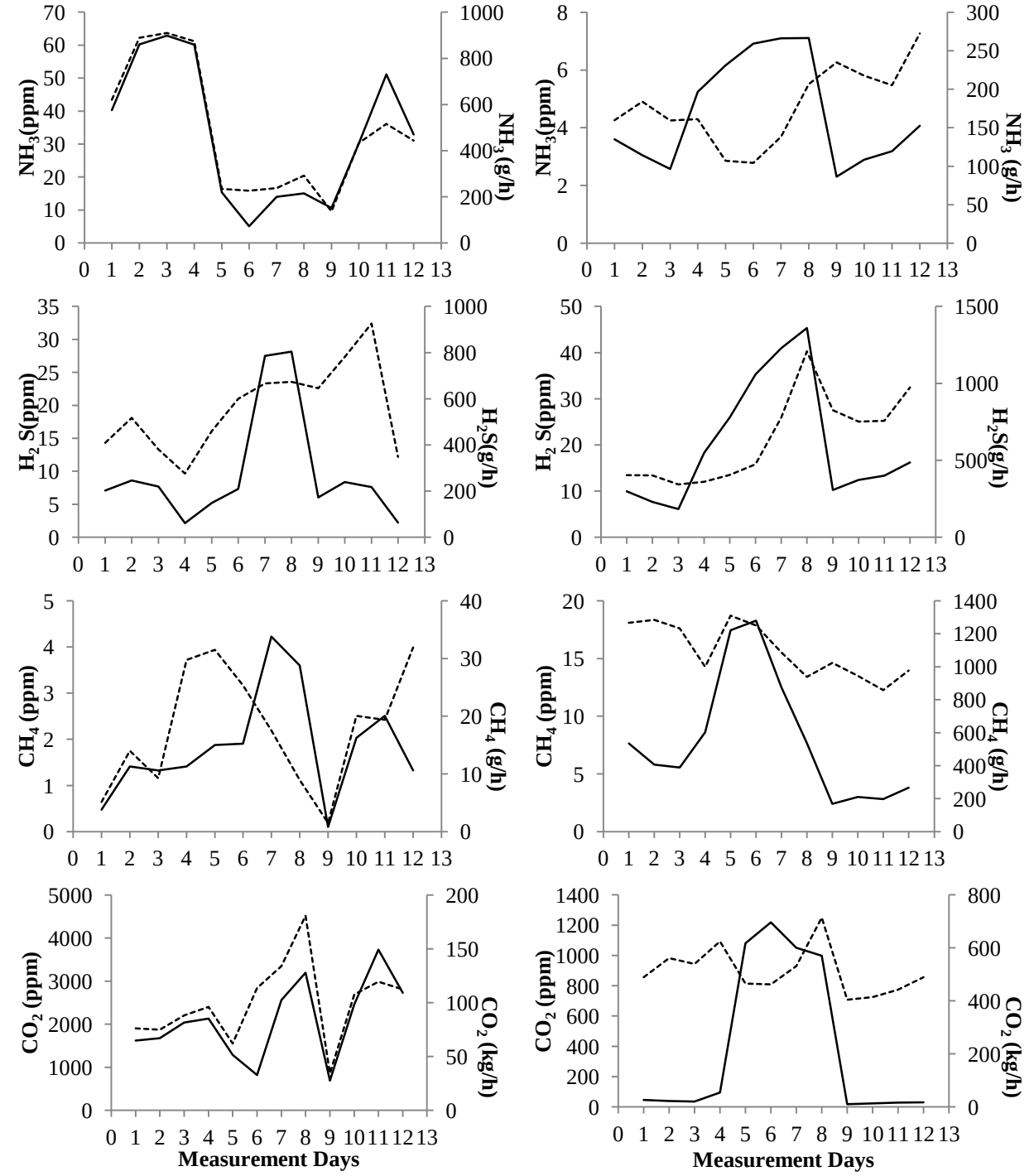

Figure 1. Pollutant gas concentration in monitored broiler houses

The hourly mean average emissions rates obtained from all three houses for NH_3, H_2S, CH_4 and CO_2 were 630 $g.h^{-1}$, 2.10 $g.h^{-1}$, 9.22 $g.h^{-1}$ and 141$kg.h^{-1}$, respectively. It seemed that the pollutant gas emissions rates from monitored broiler houses were lower than broiler houses in USA when compare with studies (Redwine et al., 2002, Burns et al., 2003, Li et al., 2008, Burns et al., 2008) in literature. The pollutant gas generation rates in animal barns vary with number of birds; type of housing; manure handling system; bird species, activity and behaviour. The Turkish broiler houses have different characteristics from American broiler houses, especially number of bird housed in the house.

Seasonal Variation in Concentration and Emissions:

Table 1 shows seasonal average of each pollutant gas concentration and emission for each broiler houses monitored in this study. At the end of the study, it was found that there are statistically a significant variation among seasons for the pollutant gas concentrations and emissions (Table 2, $P<0.01$, $P<0.05$).

Table 1.Seasonal average pollutant gas concentrations and emissions

Pollutant	Season	Concentrations			Emissions		
		H1	H2	H3	H1	H2	H3
NH_3 (ppm, $g.h^{-1}$)	Winter	57.63	17.31	26.77	798.59	176.48	445.60
	Summer	4.43	3.71	6.20	135.57	255.93	116.79
H_2S (ppb, $mg.h^{-1}$)	Winter	13.84	20.99	23.63	182.22	487.10	172.97
	Summer	12.56	23.85	27.55	314.24	1106.10	391.31
CH_4 (ppm,$mg.h^{-1}$)	Winter	1.82	2.61	2.28	9.25	23.20	11.94
	Summer	17.08	16.38	13.59	482.96	977.73	210.62
CO_2 (ppm,$kg.h^{-1}$)	Winter	2095.99	3064.00	2334.37	74.64	78.69	96.12
	Summer	969.04	950.82	765.56	30.65	62.00	14.30

Table 2. Seasonal variations among pollutant gas concentrations and emissions

Season		Concentrations				Emissions			
		NH_3 (ppm)	H_2S (ppb)	CH_4 (ppm)	CO_2 (ppm)	NH_3 ($g.h^{-1}$)	H_2S ($g.h^{-1}$)	CH_4 ($g.h^{-1}$)	CO_2 ($kg.h^{-1}$)
Winter	Ort	31.77^a	19.75^b	2.56	2495^a	442^a	279^b	15.88^b	82.71^b
	Max	93	42	7.2	9518	2389	2727	130.2	500
	Min	1.89	3.65	0.38	100	0.01	0.01	0.01	0.01
	SD	10.04	2.96	1.04	1279	216	164	13.76	60
Summer	Ort	4.78^b	21.32^a	15.68	895^b	169^b	604^a	557^a	221^a
	Mak	10.39	58.59	20.8	1663	952	5024	3731	861
	Min	2.26	5.17	8.95	505	8.92	19.74	22.76	1.88
	SD	1	6.39	1.44	242	100	294	354	57.2
P value		**	*	N.S.	**	**	*	N.S.	*

a, b, c; Means in a column with different superscripts significantly differ. N.S.: Non Significant *p<0.05, **p<0.01

Diurnal Pattern of Pollutant Gas Concentrations and Emissions:

The pollutant gas concentrations and emissions obtained in day and night measurements time were given in Table 3. The differences between day and night time concentrations and emissions were statistically significant, as seen in Table 3 ($P<0.01$, $P<0.05$). Diurnal pattern or variations were closely related to variations of house ventilation rates and indoor temperature. In the day time, ventilation rates were higher than those in the night time due to the indoor temperature. Therefore, pollutant gas concentrations in the day time were higher than those in the night time.

Table 3. The pollutant gas concentrations and emissions in day and night time

Time		Concentrations				Emissions			
		NH_3 (ppm)	H_2S (ppb)	CH_4 (ppm)	CO_2 (ppm)	NH_3 ($g.h^{-1}$)	H_2S ($g.h^{-1}$)	CH_4 ($g.h^{-1}$)	CO_2 ($kg.h^{-1}$)
Day Time	Avg	16.01[b]	19.40[b]	8.85	1241.21[b]	759[a]	5.16[b]	11.15	152.15[a]
	Max	42.24	60.3	12.41	3417.23	3514	20.39	45.43	622.31
	Min	2.1	4.28	4.59	300.62	7.53	0.03	0.02	1.28
	SD	10.33	9.96	1.96	575.98	940	6.21	10.19	196.19
Night Time	Avg	23.03[a]	25.04[a]	9.18	2193.26[a]	514[b]	10.84[a]	12.48	136.56[b]
	Max	51.83	61.15	14.14	5615.41	2552	44.22	97.99	654.41
	Min	3.05	7.7	4.43	434.1	4.46	0.01	0.01	0.96
	SD	12.51	11.99	2.23	976.88	601	9.74	16.11	169.34
P value		*	*	**N.S.**	**	**	**	**N.S.**	**

a, b, c; Means in a column with different superscripts significantly differ. N.S.: Non Significant *p<0.05, **p<0.01

Conclusions and Outlook

1. The differences of monitored three broiler houses demonstrated that house design had considerable effects on pollutant gas concentrations.
2. It was found that there were significant seasonal variations between pollutant gas concentrations and these variations originated from indoor environmental conditions such as temperature, relative humidity and ventilation rates in monitored houses.
3. Pollutant gas emissions obtained in this study are lower than the emission rates obtained in similar studies in USA. However, our results were comparable with the concentrations and emissions calculated in European studies as house design, ventilation system and bird diet applied in Turkish broiler farms are very similar to those employed in European countries.
4. The concentrations and emissions for some pollutant gases were higher than optimum thresholds for birds and workers. Especially, NH_3 concentration in the monitored broiler houses was a main problem for indoor air quality.
5. This study is one of the first comprehensively study about determination of pollutant gas concentration and emissions in Turkey. The more similar studies in Turkey are needed to confirm the results and to form a emission inventory.

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