Mitigating particulate matter, ammonia, and airborne bacteria generation of cage-free litter by spray of acidic electrolyzed water

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Introduction

Shifting from conventional cage to cage-free egg production system is occurring due to increasing public concerns or perception about animal welfare. However, there exist numerous challenges exist in cage-free facilities. One such challenge is elevated levels of particulate matter (PM), ammonia, and airborne bacteria due to accumulation of litter on the floor and hen activities on it. Spray of acidic electrolyzed water (AEW) to mitigate PM levels and disinfect the environment in hen housing has been reported. The objectives of this lab-scale study were (1) to test the effect of spray dosage, pH value, and free chlorine (FC) concentration of AEW on PM, NH_3 and airborne bacteria generation and emissions; and (2) to identify the best combination of AEW spray dosage, pH, and FC concentration in terms of reduction in PM, NH_3, and airborne bacteria levels.

Materials and Methods

Four dynamic emission chambers (DEC's, 86×46×66 cm each, **fig. 1**) in an environmentally-controlled room were used for the evaluation. Litter samples from a commercial aviary hen house (**fig. 1**) was obtained and used in the study. Litter in the treatment DECs was sprayed with AEW once a day between 11:30 and 12:00 h. A metal rake and a step motor were used to till litter to mimic bird-scratching activities on the litter.

Figure 1. The acidic electrolyzed water (AEW)-spraying experimental setup

Spraying was done within 10 min once a day for 5 consecutive days. A no-spray regimen was used as the control. Three spray dosages of **25, 50, and 75 mL [kg dry litter]$^{-1}$d^{-1}** and three **pH values of 3, 5, and 7** at a free-chlorine concentration of **200 mg L^{-1}**, i.e., a total of 9 treatment combinations were tested and compared to the control (no spray). Air temperature (T), relative humidity (RH), and ventilation rate (VR) of the DECs were controlled to nearly identical conditions (i.e., T=21°C, RH=60%, and VR=6 L min^{-1}) before spraying the AEW. Emissions data were collected with an automated data acquisition system (**fig. 2**).

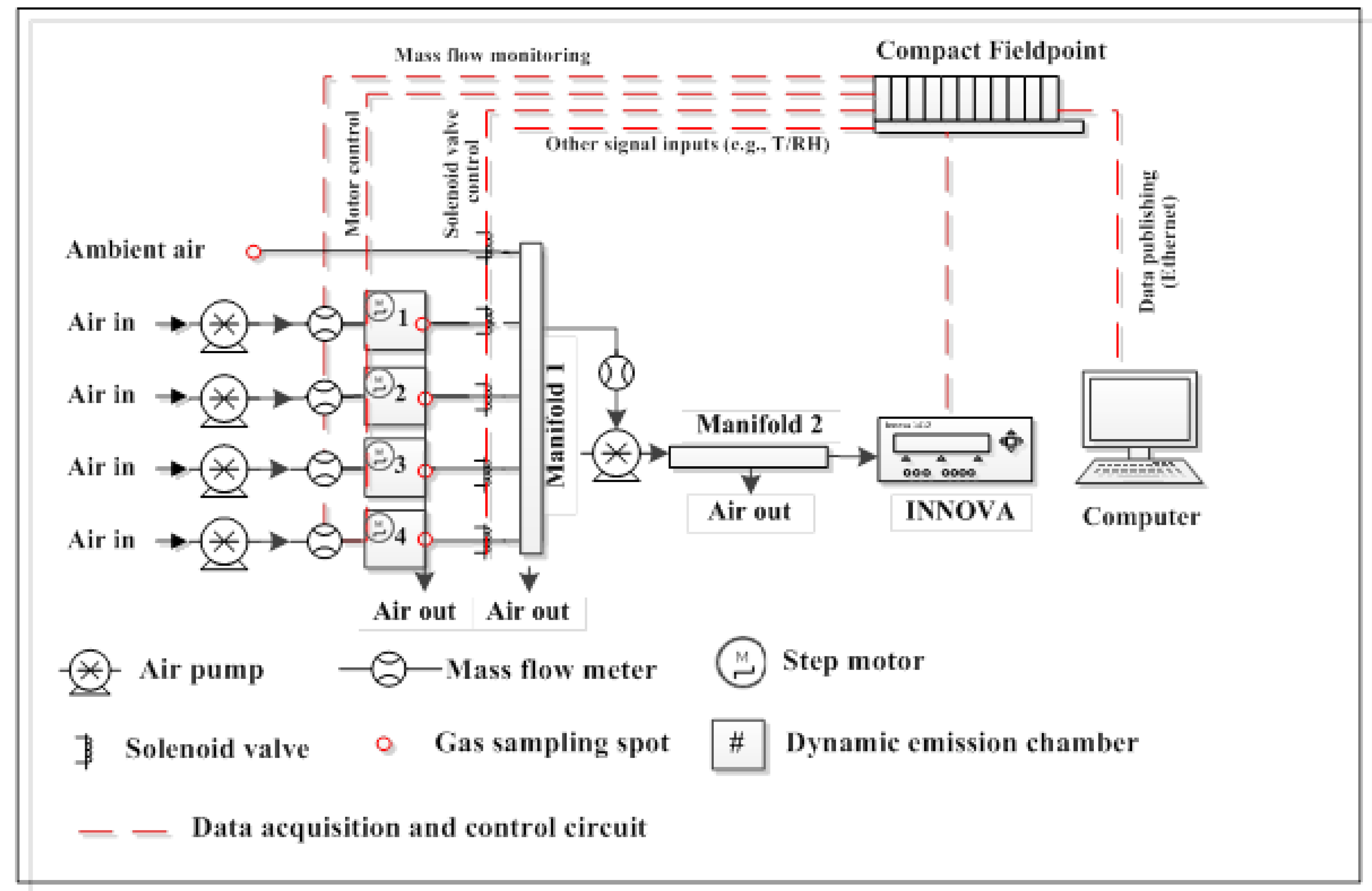

Figure 2. Data acquisition and control system used in the gaseous emissions experiment

Results

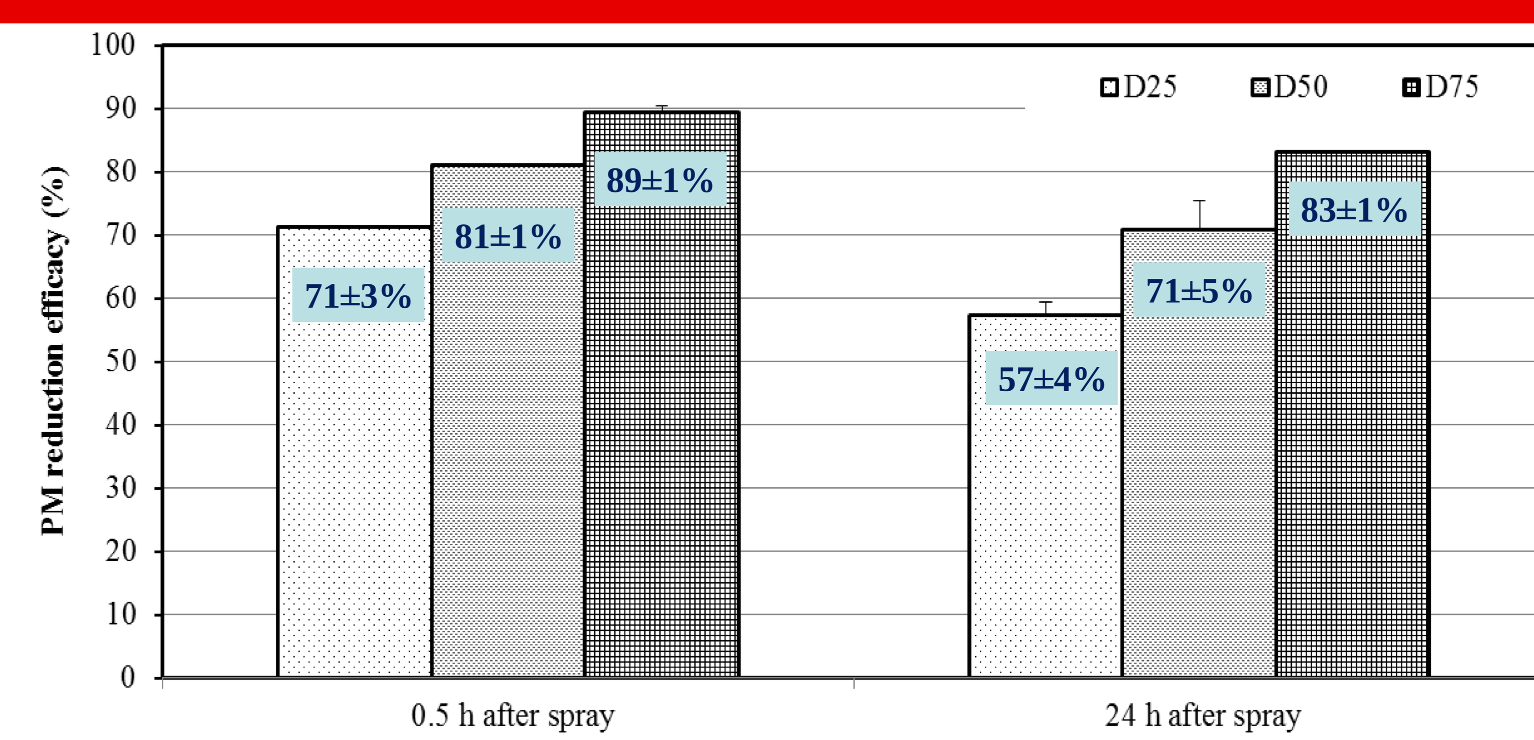

Figure 3. Reduction in particulate matter concentration 0.5 and 24 h after the spray

Higher spray dosages led to significantly lower emissions of PM (**fig. 3**), with PM reduction efficiency of 71, 81, and 89% for D25, D50, and D75, respectively.

Table 1. Ammonia emission rates (g [kg dry litter]$^{-1}$d^{-1}) (mean±SD, n=3)

Control	Treatments			
No spray	Spray dosage	pH=3	pH=5	pH=7
0.53 ± 0.02^{b}	D25	$0.70\pm0.19^{b,C}$	$0.91\pm0.25^{b,C}$	$1.78\pm0.33^{a,C}$
0.64 ± 0.08^{c}	D50	$2.27\pm1.29^{b,B}$	$2.85\pm0.86^{a,B}$	$4.41\pm0.53^{a,B}$
0.64 ± 0.12^{d}	D75	$3.68\pm0.46^{c,A}$	$5.44\pm1.07^{b,A}$	$8.97\pm0.84^{a,A}$

Note: D25, D50, and D75 represent spray dosages of 25, 50, and 75 mL [kg dry litter]$^{-1}$d^{-1}. The row means for a spray dosage (row) with a, b, and c indicate significant differences among different pH levels (P<0.05); whereas the column means for a pH value with A, B, and C indicate significant differences among different spray dosages or control (P<0.05).

In the treatment DECs, spraying higher dosages resulted in significantly higher NH_3 emission rates (ERs) (P<0.05) (**Table 1**). For example, NH_3 ER of D75 was 5-6 times that for D25 for all pH levels due to the higher litter moisture (LMC, 22.6% vs.13.0%). The NH_3 emissions in all nine treatment combinations were higher than emissions of the control (no spray), although the elevated NH_3 emissions for D25-pH3 and D25-pH5 were not significantly different from that of the control (P=0.81, P=0.47).

Spraying AEW of D25-pH3 had the highest reduction efficiency on bacteria in the air and litter, thus the effect of FC on bacteria was tested for this treatment combination. The reduction efficiencies of FC200 and FC100 sprays on PM were similar, but FC200 reduced airborne bacteria level by 40-45% more than FC100 (**fig. 4**), because the litter bacteria concentrations were significantly lower under FC200 spray as compared with FC100 spray (p<0.05).

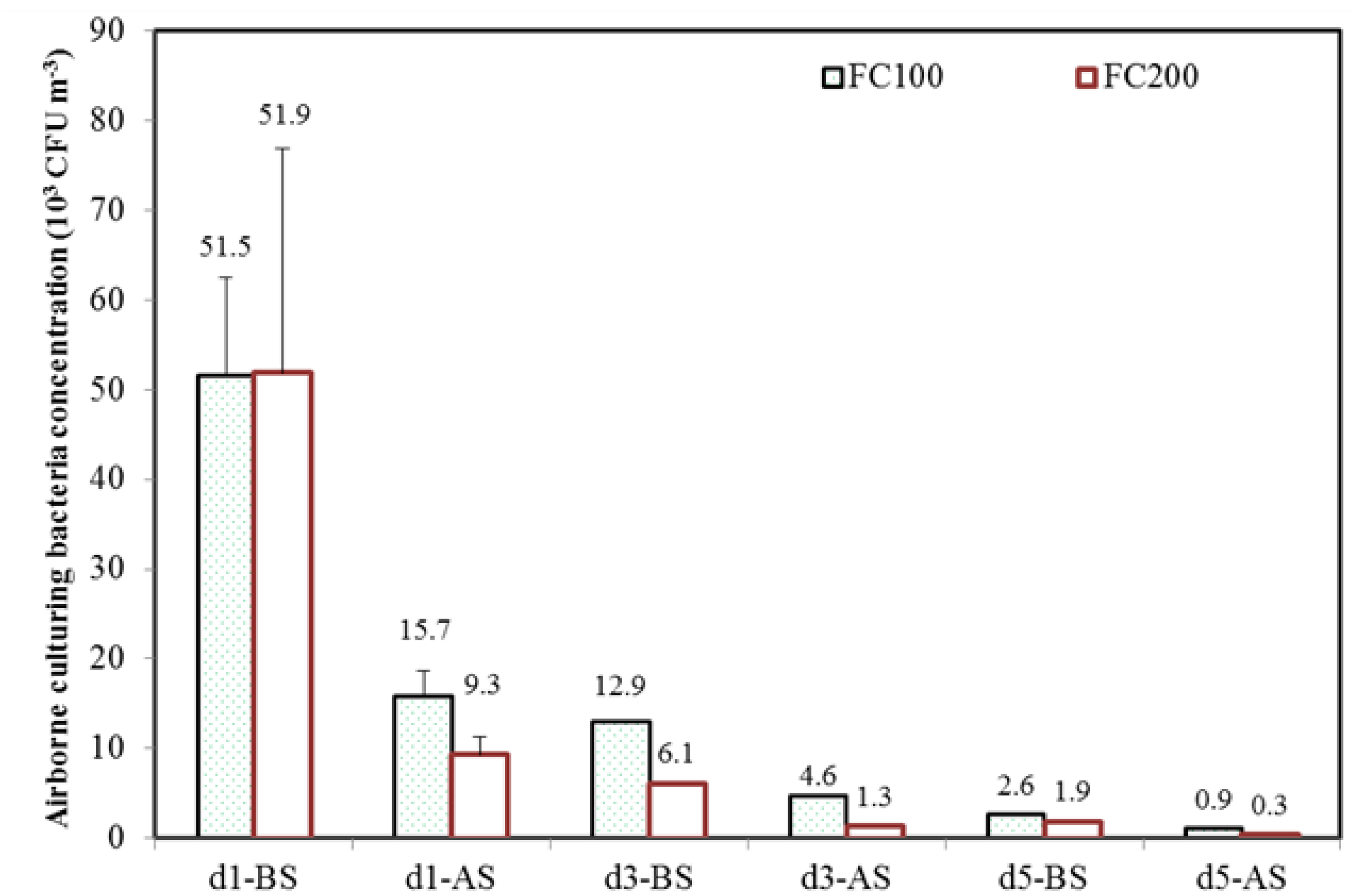

Figure 4 Difference in airborne bacteria between FC concentrations of 100 and 200 mg L^{-1} over 5 days (BS-before spray, AS-after spray; mean±SD, n=4)

Summary and Conclusions

[1] Spraying AEW resulted in 71-89% immediate reduction in PM levels at spray dosages of 25, 50, and 75 mL [kg dry litter]$^{-1}$ d^{-1}, with higher spray dosage leading to greater PM reduction. PM reductions were 57-83% 24 h after spray.

[2] Higher spray dosages led to significantly higher NH_3 emissions due to elevated litter moisture content. At a given dosage, pH7 generated 2-3 times higher NH_3 than pH3.

[3] The combination of D25-pH3 was as identified as the best option among the testes regimens. FC200 showed 40-45% higher reduction efficiency on airborne bacteria level than FC100.

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