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REDUCTION OF DUST EXPOSURE BY NEGATIVE AIR IONISATION*

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Abstract: The effect of negative air ionisation was studied in three Norwegian poultry confinement buildings with compact cages for laying hens on different farms. Total dust was measured by gravimetry of filter samples collected with stationary pumps. A reduction of dust levels by 13% from negative air ionisation was found and the difference was statistically significant. Respirable dust was measured in one building and was 20% of the total dust. Respirable dust levels measured in one building declined by 20% during ionisation, but this difference was not statistically significant.

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INTRODUCTION

Farmers are mainly exposed to particles from farm materials. Important sources of dust are grain, straw, hay, hair, excreta and soil. Microorganisms, such as moulds, bacteria and mites, may also grow on these materials. Spores from moulds and actinomycetes (filamentous, spore-forming Gram-positive bacteria) may cause fever attacks and allergic alveolitis, endotoxins (toxins from the cell walls of Gram-negative bacteria) may cause fever and bronchitis, and mite fragments and excreta may cause allergy (asthma, rhinitis). Thus, exposure to organic dust may explain the high prevalence of respiratory disease in the agricultural population [3]. Respiratory disease is also recognised as the most important work-related cause of death and the next important cause of disease in Finnish farmers [7]. Farmers are also exposed to dust from soil which may contain α-quartz, but silicosis has not been reported among Norwegian farmers. The prevention of organic dust exposure on the farm should be of prime priority to prevent respiratory disease among farmers.

Negative air ionisation systems have been developed for reduction of dust concentrations in confinement buildings. These systems emit usually negative ions because most airborne particles carry positive charge. Particles may then acquire negative charge and may be removed from the air by electrostatic attraction to constructions or by flocculation with positive charged particles and subsequent sedimentation.

Investigations on reduction of dust levels by negative air ionisation have mainly been published as not peer reviewed papers and show diverging results. Hartung [2] showed that high ion concentrations reduced the level of viable microorganisms in a small pig house by 47%. However, he used such high ion concentrations that ozone was also produced. Lower levels of ionisation had no effect on the viable microorganisms level. Parker *et al.* [6], using gravimetric dust sampling, found that dust levels changed after negative air ionisation by +4% to -11%. Mitchell [4] found in an experimental study with use of an optical particle counter that the decay rates of 1-10 μm particles increased 42-fold during ionisation in

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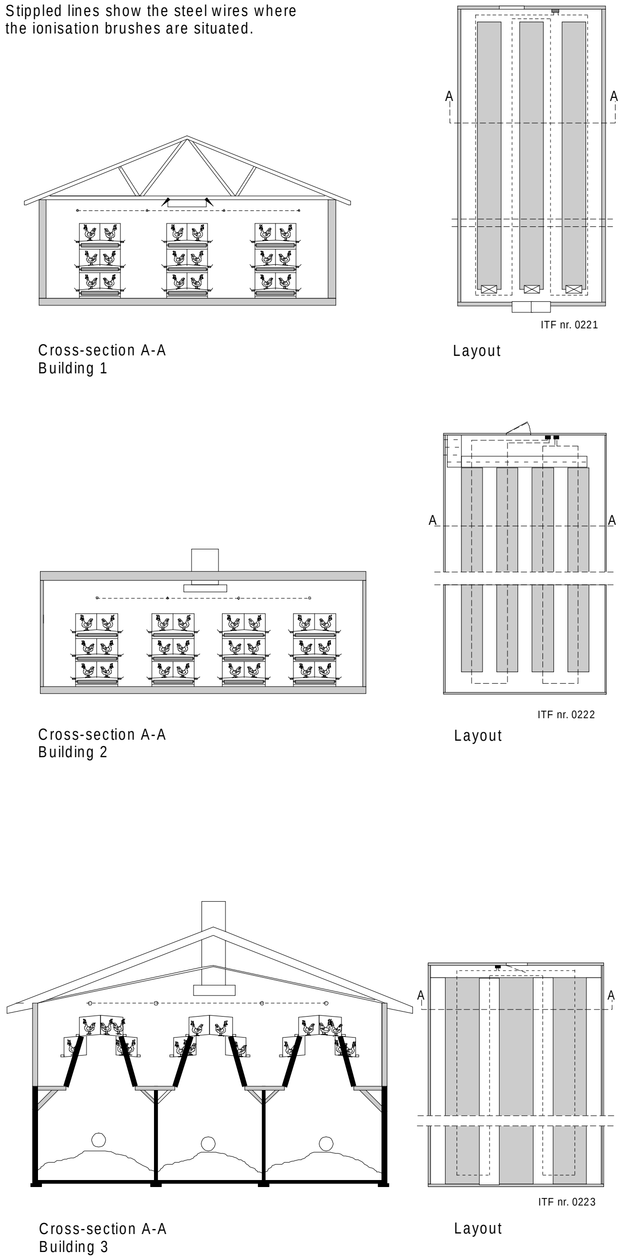

Figure 1. Cross-section and layout of the poultry confinement buildings.

an empty animal house. In a Danish study [1] of a swine confinement building, reductions of the particle concentration by 28–68% were observed for particles with different sizes using an optical particle counter, but dust concentrations measured by gravimetry showed only a reduction by 10% for total dust and 30% for respirable dust. In another study from the same institute [5] total dust levels in an experimental swine confinement building were by 23% lower and respirable dust by 26% lower during ionisation, as measured by gravimetry.

Negative air ionisation systems have been marketed since 1990 for dust abatement in animal houses in Norway. The Health and Safety Executive in Norway considered the effect of negative air ionisation systems on dust levels as uncertain and would not recommend installation of such systems. It decided, however, to initiate an investigation on the dust reduction potential of the most actual negative air ionisation system.

Table 1. Total dust concentrations measured in 5 experiments including one week with ionisation and one week without ionization.

Building	Experiment	Ionisation	Concentration of total dust, mg/m^3				
			N	AM[a]	SD[b]	GM[c]	GSD[d]
1	1	yes	5	0.87	0.23	0.85	1.30
1	1	no	4	0.90	0.12	0.89	1.15
1	2	yes	7	0.99	0.08	0.99	1.08
1	2	no	7	0.93	0.26	0.89	1.44
2	1	yes	7	1.29	0.26	1.27	1.09
2	1	no	7	1.44	0.45	1.39	1.32
2	2	yes	7	1.89	0.28	1.86	1.18
2	2	no	7	2.36	0.23	2.35	1.11
3		yes	7	0.93	0.22	0.91	1.27
3		no	7	1.37	0.34	1.33	1.28
all	all	yes	33	1.21	0.44	1.14	1.41
all	all	no	32	1.45	0.42	1.32	1.48

[a] arithmetic mean; [b] standard deviation; [c] geometric mean; [d] geometric standard deviation.

Table 2. Two-way analysis of variance of log-transformed total dust concentrations.

Source of variance	df	Variance (MS)	F-test
Experiment	4	0.3011	28.38***
Ionisation	1	0.0552	5.20*
Error	59	0.0106	
Total	64		

* $p < 0.05$, *** $p < 0.001$

MATERIALS AND METHODS

The effect of negative air ionisation was studied in three poultry confinement buildings (1–3) with hens in compact cages, on three different farms situated on the Norwegian south coast (Fig. 1). Each building was equipped with the same ionisation system, Ionic 2 (Fristamat, Langeskov, Denmark). The systems were installed at a height of 2.2 m by the manufacturing company. This system emits negative ions from carbonfibre brushes mounted on steel wires at -7000 V.

Total dust was measured by gravimetry of filter samples collected with stationary pumps with a sampling time of at least 6 hours during daytime, including all work activities by the tender. Samples were collected on membrane filters with 0.8 µm pore size and 37 mm diameter in standard aerosol cassettes at a flow rate of 2 l/min. The sampler was placed on a fixed position in the central part of the confinement building. An experiment

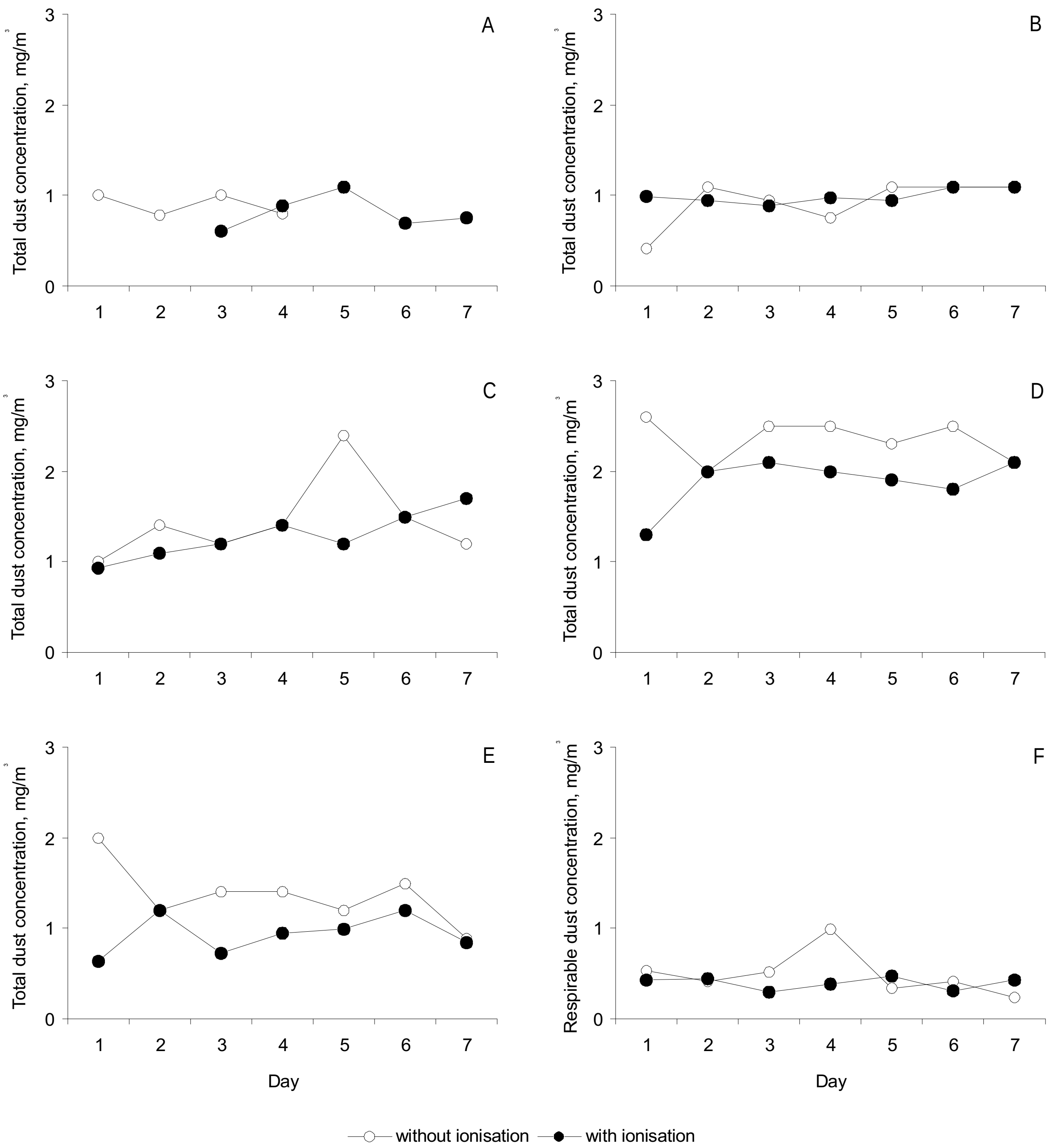

Figure 2. Dust concentrations measured during periods with and without ionisation. Total dust: (A) building 1, 1st experiment, (B) building 1, 2nd experiment, (C) building 2, 1st experiment, (D) building 2, 2nd experiment, (E) building 3. Respirable dust: (F) building 2, 2nd experiment.

consisted of one week with ionisation and one week without ionisation and measurements were carried out daily. The experiment was repeated once in two buildings. In one building respirable dust was measured with a cyclone (Model T 13026/2, Casella London Ltd., Bedfordshire, UK).

Levels of total dust were analysed by two-way ANOVA with ionisation and experiment as explanatory variables. The data were log-transformed as the standard deviation increased with the dust concentration. The effect of ionisation was estimated by the relative difference between the geometric means of dust concentrations with and without ionisation. Respirable dust levels were compared by the non-parametric Wilcoxon-Mann-Whitney test.

RESULTS

Total dust concentrations are shown in Figures 2A-E and summarized in Table 1. The largest differences in the concentration of total dust were found between buildings and periods. The overall effect of ionisation was a reduction by 13% which was statistically significant, see Table 2. Changes in total dust levels within a broad range of +11 to -32% were observed within experiments.

The concentration of respirable dust during the second experiment in building 2 was 0.39 ± 0.07 mg/m^3 with ionisation and 0.49 ± 0.24 mg/m^3 without ionisation (arithmetic mean ± standard deviation), see Figure 2F. The Wilcoxon-Mann-Whitney test was not significant. Respirable dust was 20% of the level of total dust.

DISCUSSION

The present study included three confinement buildings on different farms and experiments were also repeated in order to improve the reliability of the findings compared to previous studies. In 4 of 5 experiments lower concentrations of total dust were found in poultry confinement buildings when a negative air ionisation was in use than when the system was switched off. Although there were differences between the confinement buildings, the reduction of the dust level was never large. The small effect of negative air ionisation found in the present study is in agreement with all former studies of negative air ionisation systems using gravimetric dust measurements [1, 5, 6].

In two studies optical particle counters had been used [1, 4]. These instruments can carry out real-time measurements of particles with different sizes, which provide information that cannot be obtained by gravimetric dust sampling. However, all optical particle counters that existed at the time of the study were designed for low particle concentrations and preliminary tests in our study (results not shown) showed that long term measurements in poultry houses were not possible as the inlet became clogged with dust. The results from a Danish study [1] using an optical particle counter may be biased as dust had been sampled through a plastic tube. Ionisation may alter the electrical charge on particles from positive to negative which may lead to higher particle losses in the tube as plastic materials usually carry a positive static charge. The effect of electrical charge on particles on gravimetric dust sampling is probably small as laboratory experiments have shown that large electrical fields are necessary to produce significant effects which are seldom found in the occupational environment [8]. Another experimental study using an optical particle counter showed larger reductions in dust levels [4]. However, this study was conducted in an empty animal house and cannot be regarded as representative for the environment in confinement buildings. The activity of the animals and the animal tender should be similar during comparative measurements as they generate and whirl up dust. Similar activity levels are difficult to achieve if measurements are carried out on successive periods during a day. It was therefore chosen to measure dust exposure during a week which constituted a natural work cycle.

CONCLUSIONS

Gravimetric measurements of dust levels over prolonged periods give probably reliable results in studies on the effect of negative air ionisation systems on dust levels in confinement buildings. A small reduction of dust levels from negative air ionisation was found in the present and former studies. It is therefore likely that the effect of negative air ionisation on dust levels in confinement buildings is small.

Acknowledgements

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