MEASURED SIZE DISTRIBUTION OF DUST PARTICLES IN A HOUSE FOR FATTENING PIGS – summary of measurements

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Introduction

Dust and particles in the air environment in pig houses most likely contribute to respiratory symptoms in workers and pigs.

- Dust particles in pig houses may lead to respiratory symptoms in workers and pigs
- Studies indicate that fine and ultrafine particles deposited in the lungs and the alveoles could be especially dangerous
- A number of studies indicate that sprinkling with water (and oil) reduces the amount of dust ($mg \cdot m^{-3}$) in houses for fattening pigs
- Limited knowledge exist about the number of respirable particles of various size fractions

Aim

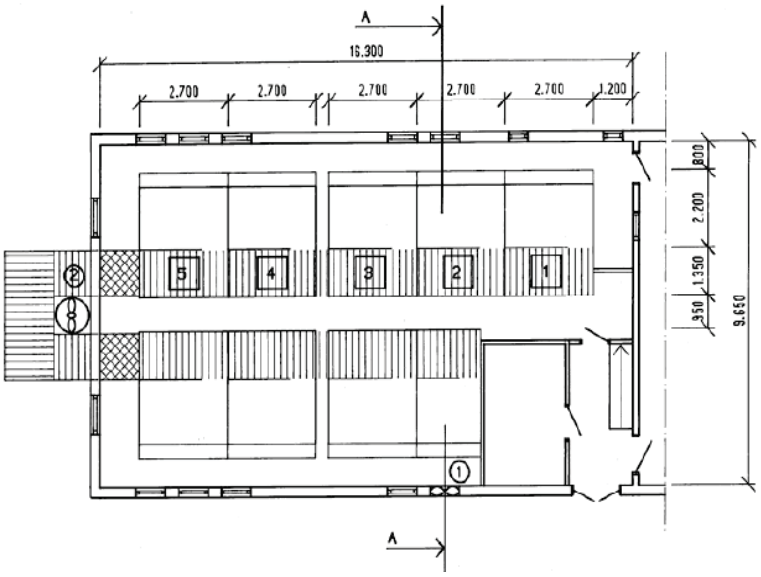
- ✓ Study the size distribution and also the effect of water sprinkling on the number of respirable particles of size fractions; 0.3–0.5 µm, 0.5-1 µm, 1-2 µm, 2-5 µm and > 5 µm

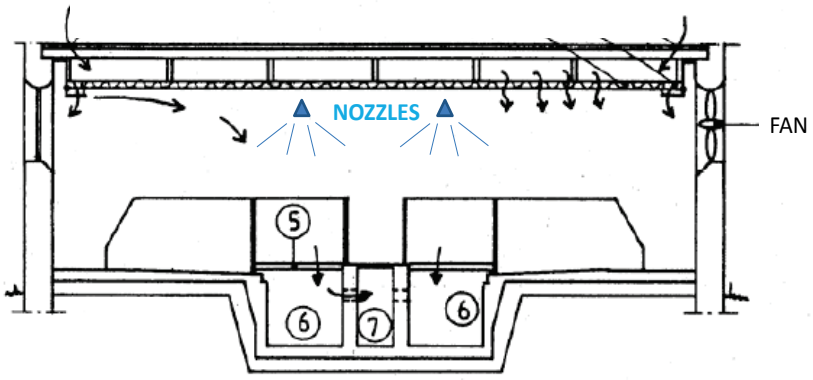
Materials and Methods

Pig barn:

- ✓ Research facility 137 m^2
- ✓ 54 fattening pigs
- ✓ 8 pens with partly slatted floor

Pig barn





Design and cross section of the pig barn

Sprinkling:

- ✓ Container with water
- ✓ Pump
- ✓ Clock and timer (time relay)
- ✓ Nozzles

Nozzles (Spraying Systems Co)

- Over the slatted floor
- One over each pen -totally 9 nozzles

Straw was used as bedding material

Experimental design

Measurements of the amount of particles :

- Without sprinkling
  - Before, between and after periods with sprinkling
- With water sprinkling
  - 3 periods with sprinkling

Period			Sprinkling during periods of 18 sec		Amount of water
No.	*Dates*	*No. of Days*	*Time of day*	*Times per hour*	*liter·m^{-2}·day^{-1}*
1	Oct 22 – Oct 25	3	5.30 am to 6 pm	2	~1
2	Oct 29 – Nov 1	3	5.30 am to 6 pm	1	~0.5
3	Nov 5 – Nov 8	3	5.30 am to 6 pm	0.5	~0.25

Pig weight ~80 – 100 kg

Ventilation rate kept constant at ~96 m^{3} pig^{-1} hour^{-1}

Measurements

Inside the barn with pigs:

- Amount of particles of different size

  0.3 – 0.5 µm

  0.5 - 1 µm

  1 - 2 µm

  2 - 5 µm

  > 5 µm

  (Particle counter Rion KC01B)

Particle counter Rion KC01B

- Temperature ~1.8 m above floor
  (Thermocouples type T)

- RH ~1.8 m above floor
  (Hygromer®-C80 sensors from Rotronic and wet and dry temperature)

Outdoor climate

- - Temperature and RH data from a nearby meteorological station

Particles were counted six times every hour. Average values for every 60 minutes were used for evaluation

Temperature, and relative air humidity (RH), were recorded using sensors connected to a logger and a computer. Data was recorded each minute and average values for every 60 minutes were used for evaluation.

Results

Temperature and Humidity

Average values of temperature and relative humidity during periods with and without sprinkling

Period of the days	**Temperature**						**Relative Humidity,** RH					
	Inside the House Mean, °C *(SD)* *N*[1]			Outdoors Mean, °C *(SD)* *N*[1]			Inside the House Mean, *% (SD)* *N*[1]			Outdoors Mean, *% (SD)*		*N*[1]
No Sprinkling												
Whole days 0 AM to 12 PM	17.2	*(3.2)*	469	8.6	*(4.4)*	468	70	*(5.6)*	*469*	89	*(9.0)*	468
Daytime 6 AM to 6 PM	17.5	*(3.3)*	*240*	9.2	*(4.4)*	*240*	71	*(5.7)*	*240*	87	*(9.7)*	*240*
Night-time 0 AM to 6 AM + 6 PM to 12 PM	16.9	*(3.2)*	*229*	8.0	*(4.3)*	*228*	69	*(5.5)*	*229*	90	*(8.0)*	*228*
Sprinkling												
Whole days 0 AM to 12 PM	14.9	*(1.6)*	211	7.0	*(2.4)*	*211*	75	*(3.9)*	*211*	88	*(8.9)*	*211*
Daytime 6 AM to 6 PM	15.2	*(1.8)*	*103*	7.8	*(1.8)*	*103*	76	*(3.1)*	*103*	85	*(9.6)*	*103*
Night-time 0 AM to 6 AM and 6 PM to 12 PM	14.5	*(1.6)*	*108*	6.2	*(2.6)*	*108*	73.1	*(4.0)*	*108*	91	*(7.1)*	*108*

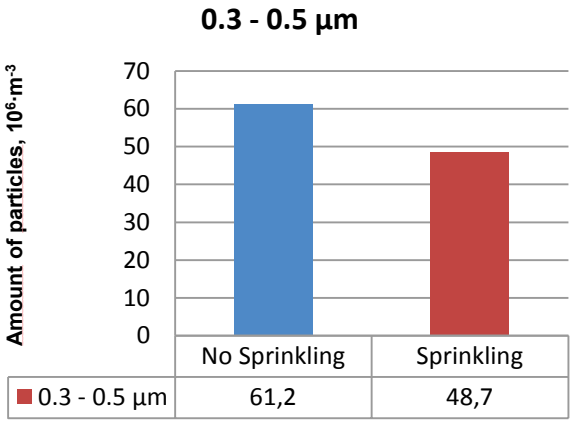
[1] N = No. of hours with measurements

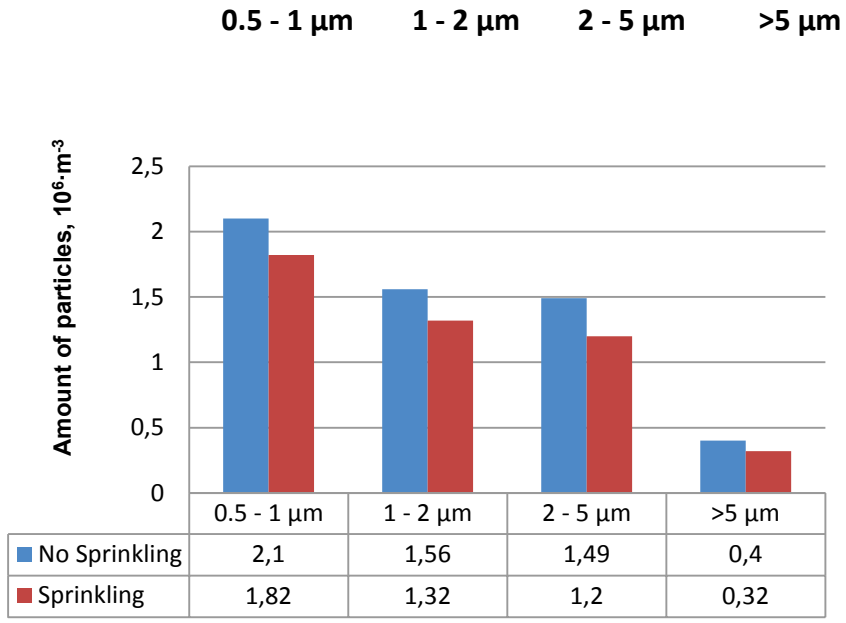
Average number of particles of different size during periods without and with sprinkling

Period of the days	Size fraction										
	0.3 – 0.5 µm		0.5 - 1 µm		*1 - 2 µm*		2 - 5 µm		*> 5 µm*		*N*[1]
	Mean, 10^6 m^{-3}	(SD)	Mean, 10^6 m^{-3}	(SD)	Mean, 10^6 m^{-3}	(SD)	Mean, 10^6 m^{-3}	(SD)	Mean, 10^6 m^{-3}	(SD)	No.
No Sprinkling											
Whole days 0 AM to 12 PM	61.2	*(34.7)*	2.09	*(1.08)*	*1.56*	*(1.07)*	1.49	*(1.13)*	*0.40*	*(0.31)*	469
Daytime 6 AM to 6 PM	60.6	*(33.4)*	*2.31*	*(1.17)*	*1.94*	*(1.28)*	1.89	*(1.33)*	*0.51*	*(0.36)*	240
Night-time 0 AM to 6 AM + 6 PM to 12 PM	61.8	*(36.0)*	*1.88*	*(0.94)*	*1.17*	*(0.59)*	1.07	*(0.66)*	*0.29*	*(0.19)*	229
Sprinkling											
Whole days 0 AM to 12 PM	48.7	*(13.8)*	1.81	*(1.07)*	*1.32*	*(0.71)*	1.20	*(0.74)*	*0.32*	*(0.21)*	211
Daytime 6 AM to 6 PM	46.0	*(10.7)*	*2.12*	*(1.21)*	*1.64*	*(0.76)*	1.51	*(0.80)*	*0.40*	*(0.23)*	103
Night-time 0 AM to 6 AM and 6 PM to 12 PM	51.3	*(15.9)*	*1.53*	*(0.84)*	*1.02*	*(0.50)*	0.91	*(0.55)*	*0.25*	*(0.16)*	108

[1] N = No. of hours with measurements

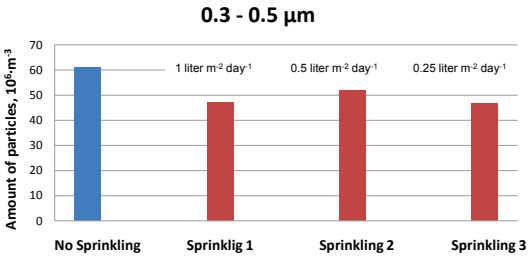
Average reduction with sprinkling

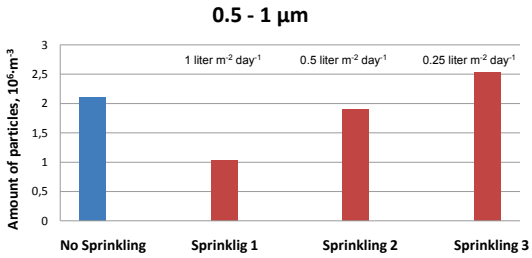


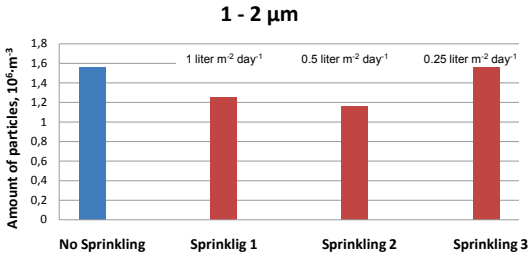


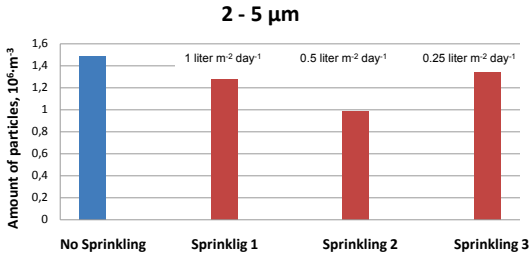
- **Reduction with sprinkling was significant for all sizes of particles (ANOVA; $p<0.05$)**

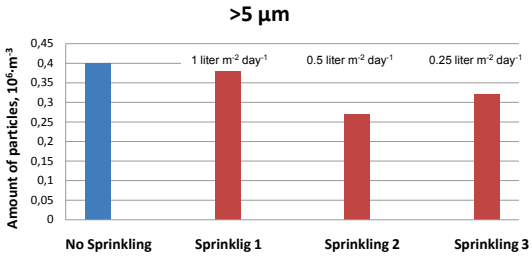
Amount of particles in experiments with different amount of water



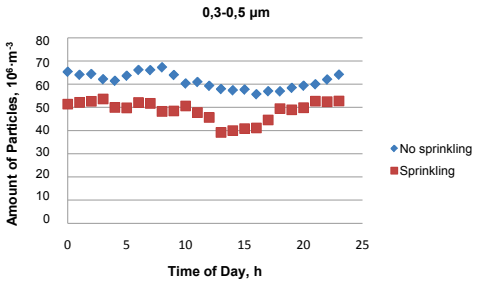


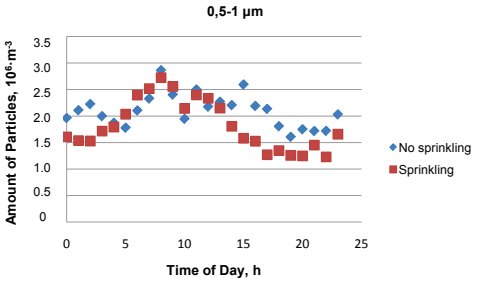


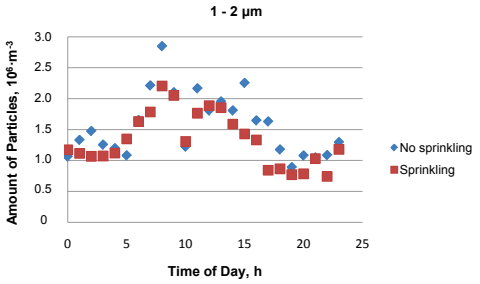


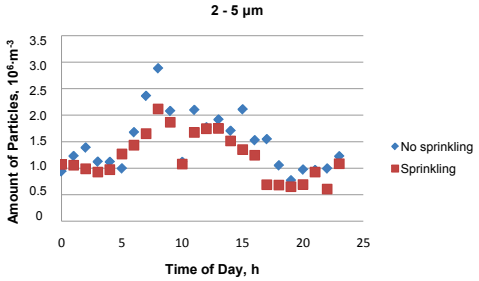


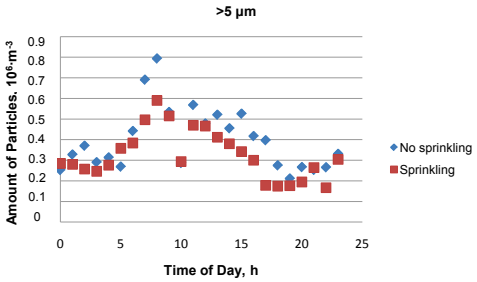
Diurnal variation of the amount of particles











Correlations

	Sprinkling *Correlation*	Barn Temperature *Correlation*	Humidity in Barn *Correlation*	Outdoor Temperature *Correlation*
0.3 – 0.5 µm	-0,191***	N.S.	N.S.	0,135***
0.5 - 1 µm	-0,120**	0,097*	0,144***	0,150***
1 - 2 µm	-0,113**	N.S.	N.S.	N.S.
2 - 5 µm	-0,129***	N.S.	N.S.	-0,11**
> 5 µm	-0,122***	-0,083*	N.S.	-0,14***

N.S. = Not Significant;
* = Significance level p≤0.05 ** = Significance level p≤0.01; *** = Significance level p≤0.001

Discussion and Conclusions

- Average numbers of particles in millions per m^3 during periods without sprinkling were 63 for size fraction 0.3-0-5 µm, 2.2 for 0.5-1 µm, 1.5 for 1-2 µm, 1.5 for 2-5 µm and 0.39 for particles larger than 5 µm.
- Average numbers of particles in millions per m^3 during three periods with water sprinkling were 48 for size fraction 0.3-0-5 µm, 1.8 for 0.5-1 µm, 1.3 for 1-2 µm, 1.2 for 2-5 µm and 0.33 for particles larger than 5 µm.
- Problems with some nozzles in "Sprinkling 1" and a small amount of water in "Sprinkling 3" likely limited the reduction of dust particles in the experiment
- The result suggests that sprinkling with water gives a significant reduction particles with sizes 0.3 – 0.5 µm, 0.5 - 1 µm, 1 - 2 µm, 2 - 5 µm, and > 5 µm
- The diurnal variations of the amounts of particles indicate a strong influence of the activity in the barn on the number of particles larger than > 0.5 µm
- Outdoor temperatures is likely of a large importance for occurrence of smaller particles (0.3 – 0.5 µm, 0.5 - 1 µm)
- Variation between concentrations during different days indicates a difficulty to make sure conclusions and also a need for further studies