Distribution and physicochemical properties of particulate matter in swine confinement barns

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Background and Aim

Air pollutants accumulated in confined livestock barns could impact the health of animals and staff. PM and NH_3 concentrations are typically high in enclosed livestock houses.

This present study aimed to

- investigate the distribution of PM in different size fractions
- detect levels of NH_3 in a nursery (HN) barn and a fattening (HF) barn
- analyze the physicochemical properties of $PM_{2.5}$

Method

Concentrations of PM were measured using a DustTrak[II] model 8532 aerosol monitor (TSI Inc., Minnesota, USA).

Concentrations of NH_3 were measured using a JK40-IV portable gas detector (Ji Shun'an Technology Co., Ltd., Guangdong, China).

Ultrastructural observation was conducted using a SU8010-type field scanning electron microscope (SEM, Hitachi, Tokyo, Japan).

PM and NH_3 concentrations were measured at eight points (Fig 1.) from 07:00 to 19:00 at 2-h intervals for 6-day continuous monitoring in each barn.

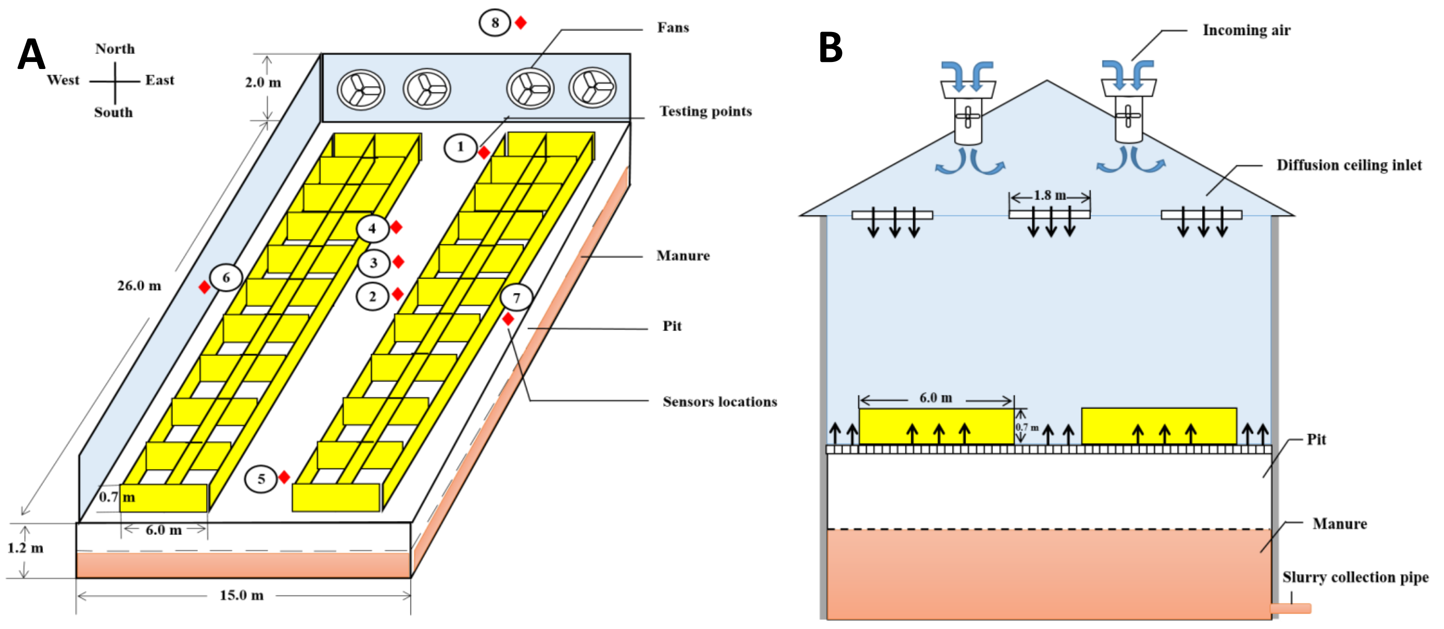


Fig 1. Plan view (A) and Schematic cross-section (B) of the barns with eight measuring points indicated.

Note: The diagram is not drawn to scale. The measuring points are shown as numbers.
① forepart; ② height of 0.5 m; ③ height of 1 m; ④ height of 1.5 m; ⑤ back; ⑥ east; ⑦ west; ⑧ outside.

Results and Discussion

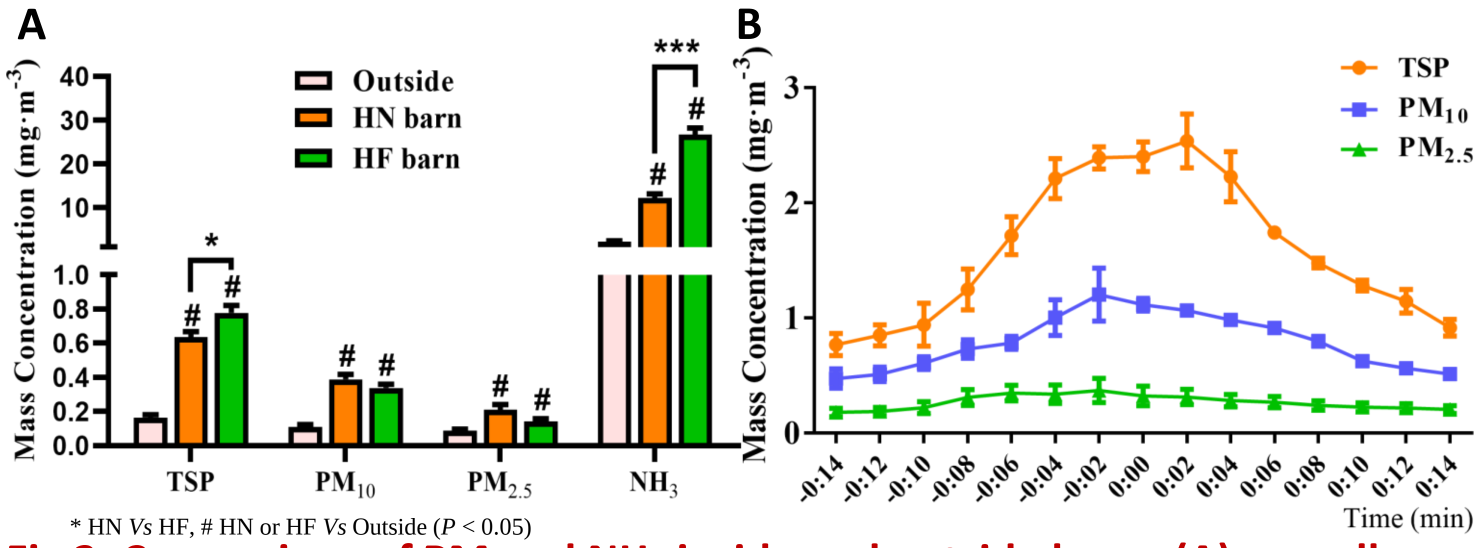
Table 1. Spatial differences of particulate matter (PM) and ammonia (NH_3) concentrations in nursery (HN) and fattening (HF) barns.

Point	HN barn				HF barn			
	PM ($mg \cdot m^{-3}$)			NH_3 ($mg \cdot m^{-3}$)	PM ($mg \cdot m^{-3}$)			NH_3 ($mg \cdot m^{-3}$)
	TSP	PM_{10}	$PM_{2.5}$		TSP	PM_{10}	$PM_{2.5}$	
1.5 m	0.787 ± 0.1^{a}	0.473±0.1	0.222±0.07	12.7±3	0.829 ± 0.3^{ab}	0.360±0.1	0.153±0.07	40.3 ± 9^{a}
1.0 m	0.739 ± 0.1^{ab}	0.445±0.1	0.217±0.08	11.9±3	0.840 ± 0.3^{ab}	0.347±0.1	0.152±0.07	40.9 ± 8^{a}
0.5 m	0.723 ± 0.1^{abc}	0.401±0.1	0.204±0.09	10.5±2	0.760 ± 0.3^{ab}	0.351±0.1	0.144±0.07	41.0 ± 8^{a}
Forepart	0.515 ± 0.2^{bc}	0.334±0.08	0.203±0.1	13.6±4	0.884 ± 0.4^{a}	0.377±0.1	0.175±0.09	37.7 ± 8^{ab}
Rear	0.475 ± 0.2^{c}	0.312±0.1	0.201±0.1	9.87±4	0.618 ± 0.1^{b}	0.272±0.06	0.120±0.06	27.2 ± 5^{cd}
East	0.634 ± 0.2^{abc}	0.385±0.1	0.203±0.08	13.2±3	0.771 ± 0.2^{ab}	0.332±0.2	0.136±0.07	31.7 ± 6^{bcd}
West	0.576 ± 0.2^{abc}	0.366±0.1	0.216±0.1	13.5±5	0.734 ± 0.2^{ab}	0.329±0.1	0.128±0.06	27.1 ± 6^{d}

Note: The values are shown as the mean ± SEM based on 7 measurements per day for 6 d at each position. Values followed by different superscripted letters are significantly different between positions ($P < 0.05$); values followed by the same letters show no significant differences.

PM and NH_3 concentrations at rear were the lowest;
TSP and NH_3 concentrations in HF barn were higher than HN barn

- Intake windows through which the fresh air entered were located in the rear of the barns, fresh air diluted the PM and NH_3 concentrations.
- The PM and NH_3 accumulated more easily in the middle and forepart of the barn.
- More feed was provided and more manure was excreted in HF barn.
- Larger PM fractions originate mainly from manure and feed.

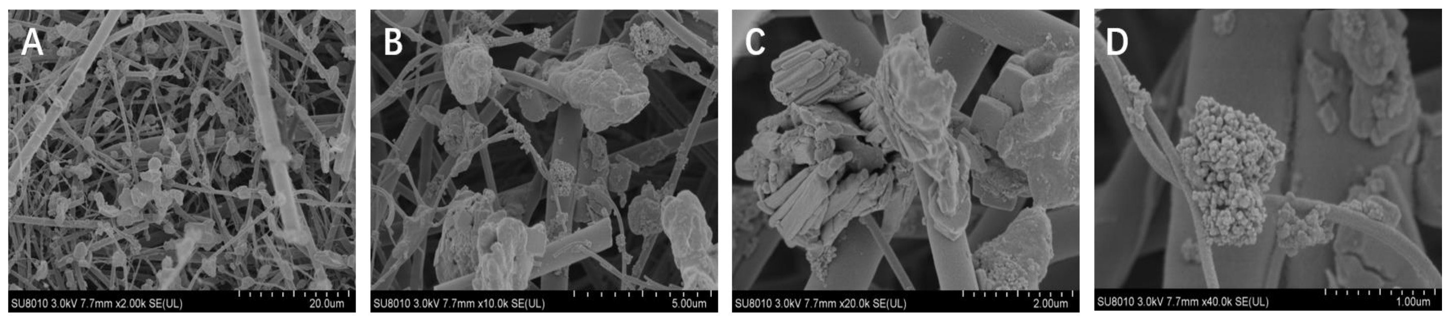


* HN *Vs* HF, # HN or HF *Vs* Outside (P < 0.05)

Fig 2. Comparison of PM and NH_3 inside and outside barns (A) as well as the variation of PM concentration before and after feeding (B).

PM and NH_3 inside the barns were higher than outside;
Feeding induced PM increased

- Pig barn is an important contributor of air pollutants to the ambient environment.



AB, particles from the HN barn; CD, particles from the HF barn; A (×2 000); B (×10 000); C (×20 000); D (×40 000).

Fig 3. Microscopic morphology of fine particulate matter ($PM_{2.5}$) collected in the pig barns.

$PM_{2.5}$ in the barns were supposedly from feed, manure, blowing dust, mineral particles

- roughly spherical and irregularly shaped particles – feed, manure
- loose, smooth surfaces of the strip-, rod-, bar-shaped – mineral, dust

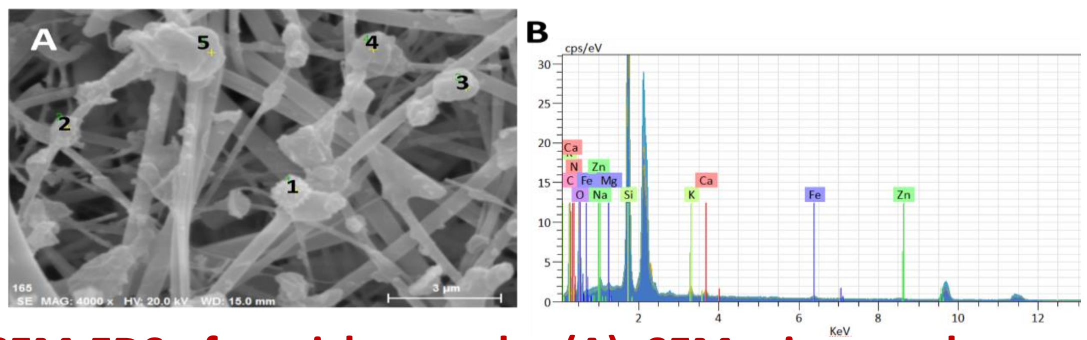


Fig 4. SEM-EDS of particle samples (A). SEM micrographs were digitized and primary feature data measurements were made (B).

Table 2. Chemical composition of PM expressed as mass percentage

Spec-trum	C	N	O	Na	Mg	Si	P	K	Ca	Fe	Zn
1	18.5	5.96	45.0	0.810	3.98	15.8	9.69	0.230	-	-	-
3	21.4	-	40.2	0.940	-	30.4	-	0.370	0.800	1.24	4.64
4	35.8	8.99	37.6	1.31	0.200	15.4	-	-	0.00	0.730	-
5	31.4	10.8	37.7	1.05	0.00	19.1	-	-	-	-	-
Mean value	24.9	7.83	40.3	1.08	1.34	19.8	8.83	0.210	0.320	0.920	5.45

$PM_{2.5}$ in the barns were supposedly from feed, manure, blowing dust, mineral particles

- The elements C, O, and Si are the major constituents of feed and skin particles.
- Dust blown from the soil is also enriched in the elements O and Si.
- $PM_{2.5}$ form pig barns was mainly organic matter.

Conclusion

- The air quality at the rear of the barns was the best; the air quality outside was better than inside.
- Feeding could increase the PM concentrations.
- It was speculated that the $PM_{2.5}$ in the barns were feed, manure, blowing dust, mineral particles and smoke from outside.

Future Plan

- To detect the specific component of $PM_{2.5}$, including OC, EC, metal and ions as well as the content of microorganism and endotoxin.
- To research the mechanism of lung tissue injury caused by $PM_{2.5}$.

No conflict of interest