Particulate Matter in a fattening pig house in Beijing, China: First Indoor and Outdoor Measurements

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Introduction

- Airborne particulate matter (PM) is an important pollutant because it can lead to serious health problems such as respiratory and cardiovascular diseases and increased mortality.

- PM can cause detrimental effects on the animal performance as well as on the health and welfare of farmers.

- Inhaled particles can penetrate in the deeper respiratory airways.

- The size of the dust particles varies from less than 0.1 micron (\(\mu m\)) to over 100 \(\mu m\).

- 80-90\% of the dust inside pig and poultry buildings is smaller than 5 \(\mu m\).
Problem Statement

- Main sources of PM in livestock houses: feed, manure, bedding, animal's skin, feathers and hair

- Distribution of airborne pollutants depends on design, location of air inlets and outlets and resulting airflows and flow patterns

- Recommendations for continuous exposure of pigs to dust specify a concentration for:
  - thoracic dust (PM$_{10}$) of 1 mg/m$^3$ (MOA)
  - respirable dust (PM$_4$) of 3 mg/m$^3$ (DFG)
Gang Qin Fen Manurial System

Part 1
Solid Fraction
- Solid manure stored in an open platform

Part 2
Liquid Fraction
- Methane byproduct
- Biogas Plant (anaerobic-aerobic treatment)
- Oxidation Pond (irrigation water)

Fresh solid manure collected with a shovel

Publication in Int. J. of Biological and Life Sciences 6:2 2010
“Pig Husbandry and Solid Manures in a Commercial Pig Farm in Beijing, China”
http://www.waset.org/journals/ijbls/v6/v6-2-17.pdf

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Regional Particle Deposition in Humans

- Head Region
  - Inhalable Dust
- Thoracic Region
  - Thoracic Dust
  - Respirable Dust
  - Respiratory Region

Dust Particle
10 microns

Human Hair
70 microns
Objectives

• Measure:

• Thoracic (inhalable) dust (less than 10 μm) penetrates the respiratory system beyond the larynx

• Respirable dust (less than 5 μm) can be inhaled and lodged deeply into the lungs
Materials and Methods

- PM$_{10}$ and PM$_{2.5}$ concentrations were continuously monitored from June to August (Beijing Summer Season) in a large scale pig farm in Beijing, by pig stage.

- Dust measured as mg (airborne dust) per cubic meter of airspace (mg/m$^3$)

- Device: Aerosol Monitor

- Principle: Scattering principle of the infrared light emitted by a laser diode and on-line measurement in 24-hour cycles. “The intensity of light scattered by a particle is a function of the particle size, shape and index of refraction”.

- Monitoring took place inside/outside a fattening pig house and inside of a farmer house.
Sampling Site: Beijing Pig Farm

Beijing:
✓ 1.8 mill. live pigs by 2008
✓ 80% large-scale pig farms

Shunyi District:
✓ 188 pig farms
✓ 34% total pig production

Map of Beijing City (Ma and Liu, 2003)
Sampling based on Pig Stages

Breeding

- **IV**: Fattening, 80-120 days
- **III**: Weaning, 30 days
- **II**: Farrowing, 35 days

Slaughter

- **I**: Gestation, 110 days
- **Al**: 4-5 days

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Materials

- DustTrak Aerosol Monitor (1; 2,5 and 10 µm nozzles)
Methods: Device location

Sampling point

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Methods: Device location

- Sampling point

2 m

y

gutter

3.00

1.00

0.05

1.00

3.79
Methods: Device location

Sampling point

farmer room
The Environmental Quality Standard for the Livestock and Poultry Farm (NY/T 388-1999)

“Ambient Air Quality Standards of Pig Farms”

<table>
<thead>
<tr>
<th>Items</th>
<th>Unit</th>
<th>Farm Area *</th>
<th>Pig Houses* (Chinese Standard)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM$_{10}$</td>
<td>mg/m$^3$</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>NH$_3$</td>
<td>ppm</td>
<td>7</td>
<td>35</td>
</tr>
<tr>
<td>CO$_2$</td>
<td>ppm</td>
<td>410</td>
<td>819</td>
</tr>
</tbody>
</table>

* The data stands for the daily mean concentration.
### Threshold Limit Values (TLVs) of PM in pig farms

<table>
<thead>
<tr>
<th>Institution</th>
<th>Size</th>
<th>TLV (mg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFG, 2004</td>
<td>PM$_{100}$</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>PM$_{4}$</td>
<td>1.5</td>
</tr>
<tr>
<td>MOA, 1999</td>
<td>PM$_{10}$</td>
<td>1</td>
</tr>
<tr>
<td>ACGIH, 1994</td>
<td>PM$_{4}$</td>
<td>3</td>
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</tbody>
</table>
### Main Results of PM$_{10}$

<table>
<thead>
<tr>
<th>Sampling Place</th>
<th>Mean</th>
<th>SD</th>
<th>Minimum</th>
<th>Median</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fattening house</td>
<td>1,04</td>
<td>0,51</td>
<td>0,02</td>
<td>0,92</td>
<td>4,87</td>
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<tr>
<td>Farmer room</td>
<td>0,14</td>
<td>0,10</td>
<td>0,02</td>
<td>0,10</td>
<td>1,93</td>
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<tr>
<td>Outside fattening house</td>
<td>0,08</td>
<td>0,08</td>
<td>0,00</td>
<td>0,06</td>
<td>1,12</td>
</tr>
</tbody>
</table>

### Main Results of PM$_{2.5}$

<table>
<thead>
<tr>
<th>Sampling Place</th>
<th>Mean</th>
<th>SD</th>
<th>Minimum</th>
<th>Median</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fattening house</td>
<td>0,20</td>
<td>0,11</td>
<td>0,06</td>
<td>0,18</td>
<td>4,49</td>
</tr>
<tr>
<td>Farmer room</td>
<td>0,09</td>
<td>0,05</td>
<td>0,02</td>
<td>0,08</td>
<td>0,55</td>
</tr>
<tr>
<td>Outside fattening house</td>
<td>0,20</td>
<td>0,07</td>
<td>0,09</td>
<td>0,19</td>
<td>1,47</td>
</tr>
</tbody>
</table>
Results of the PM10 concentrations

- Concentration, mg/m$^3$
- Fattening house
- Farmer room
- Outside fattening house

Chinese TLV
Results of the PM2.5 concentrations

- Concentration, mg/m³

- fattening house
- farmer room
- outside fattening house

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PM daily concentration in a Fattening House

![Graph showing PM concentrations over time with peaks at 7 am and 6 am, labeled as Cleaning? and Feeding 7 am respectively.]

Cleaning? Feeding 7 am
PM daily concentration in a Weaning House

Cleaning?
Feeding 5-7 am

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Conclusions

• PM$_{10}$ (thoracic dust) was highest in indoor measurements (0,02-4,87 mg/m$^3$)

• PM$_{2,5}$ (respirable dust) was highest in indoor measurements (0,06-4,49 mg/m$^3$)

• PM$_{10}$ indoors surpassed the Chinese TLVs (1 mg/m$^3$)

• Measurements were performed in Summer Season in Beijing and:

  • There was a high ventilation rate in summer compared with winter. Indeed, higher PM concentrations can be expected in winter!

• Long term health risk for farmers!

• Feed (ad-libitum) may produce considerable feed loses in the form of dust. Dry meals are mainly supplied to pigs. Wet meals could reduce loses.
Thanks for your attention!