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Particulate Matter emitted from a Pig Farm in Beijing: A Preliminary Study

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***Abstract*—During the summer 2010 the concentrations of particulate matter or dust particles in the form of fractions sized up to 10 µm (PM10), 2,5 µm (PM2,5) and 1 µm (PM1) from a commercial pig farm in Beijing were measured inside of four pig barns, i.e. gestation, farrowing, weaning and fattening. The above mentioned fractions were measured by using the scattering principle of the infrared light emitted by a Ga-As laser diode and by on-line measurement in 24-hour cycles. For fraction PM10 the mean concentration was 0,64 mg/m^3, for PM2,5 the mean value was 0,29 mg/m^3 and for PM1 the mean concentration obtained was 0,27 mg/m^3.**

I. INTRODUCTION

Atmospheric pollution can be described as a change in the substances present in the ambient air which are likely to be harmful to humans, living organisms and to the natural environment. In this sense, 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 between the most important [3].

Particulate matter (PM) from livestock facilities is regarded as an indoor pollutant that 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, compromising animals' and human's respiratory health, contributing to increased occurrence of chronic cough, chronic bronchitis, allergic reactions and asthma-like symptoms among livestock farmers. For instance, in pig barns, feed, manure, bedding, animal's skin and hair have been identified as the main sources of PM. The generation of PM, its suspension in the air and its release outside of the pig facilities will depend on the kind of housing, management, husbandry techniques, feeding, pig stage and environmental factors related with the climatic conditions [3].

Climate or season, which is intrinsically related to ventilation rates, also affects the PM concentrations inside of the livestock facilities. Because of higher ventilation rates in summer compared with winter, lower PM concentrations and higher emission rates can be expected in the summer, whereas higher PM concentrations and lower emission rates can be expected in winter.

When the dust measurements are being taken in relation to health effects, the sampling conventions relate to the penetration of the aerosol to regions of the respiratory tract and its aerodynamic diameter. The definition of these conventions has been agreed by the European Committee for Standardization (CEN), the International Standards Organisation (ISO) and the American Conference of Governmental Industrial Hygienists (ACGIH), and is defined as follows [4],

-The thoracic fraction, which includes the respirable fraction, is defined as the mass fraction that penetrates the respiratory system beyond the larynx. These particles have a mean aerodynamic diameter of 11,64 µm.

-The respirable fraction is defined as the mass fraction that penetrates to the unciliated airways of the lung, known as the alveolar region, where gaseous exchange takes place. The respirable fraction has a mean aerodynamic diameter of 4,25 µm. [4]

Dust is mostly measured as mg (airborne dust) per cubic meter of airspace (mg/m^3). The size of the dust particles varies from less than 0,1 micron (µm) to over 100 µm. The important fractions are inhalable dust (less than 10 µm) and respirable dust (less than 5,0 µm). About 80-90% of the dust inside pig and poultry buildings is smaller than 5 µm and can be inhaled deeply into the lungs [1].

Therefore, the objective of this paper is to present the results of measuring dust concentrations in fractions PM10, PM2,5 and PM1during the summer season of 2010 in a large commercial pig farm located in Beijing, China.

A. Definitions

Particulate matter (PM) are fine solid or liquid particles suspended in a gaseous medium (same as aerosol).

PM1 Particulate matter which passes through a size selective inlet with a 50% efficiency cut-off at 1 µm aerodynamic diameter.

PM2,5 Particulate matter which passes through a size selective inlet with a 50% efficiency cut-off at 2,5 µm aerodynamic diameter.

PM10 Particulate matter which passes through a size selective inlet with a 50% efficiency cut-off at 10 µm aerodynamic diameter

II. MATERIALS AND METHODS

A. Dust concentration measurement

PM10, PM2,5 and PM1 concentrations were continuously monitored from April to August, 2010 in a pig farm located in Beijing by a sampler TSI Dust Track Model 8520 Aerosol monitor (TSI Inc., USA). The instrument measures aerosol particles based on the scattering principle of the infrared light emitted by a Ga-As laser diode. The instrument was able to measure aerosol particles of 0,1-10 µm diameter with a measurement range of 0,001-100 mg/m^3 and a resolution of ±0,1% or ±0,001 mg/m^3. The instrument was powered by batteries and the data was stored in the memory that could be downloaded to a computer [2].

B. Animal confinement technology description

The monitoring took place inside of four pig barns. The selection of the barns was based on the pig stages, i.e., gestation, farrowing, weaning and fattening. The pig barns were divided into pens (number varied depending on the type of pig barn). Among the pens there was a service passage. Gestation and fattening pens had concrete floors while farrowing and weaning pens had slotted floors. The nominal barn capacity was of 200-300 pigs. At the time of monitoring the occupancy was of 90-100%. Piggery wastewater flowed through the gutter channels and was discharged by gravity into a main channel with direction to the biogas plant. Pigs were fed in different basis with a wet or dry feed mixture depending on the pig growing stage. The ventilation system was either natural or forced. Under natural ventilation system (weaning and fattening barns) windows and doors were opened during day-night in summer and were closed in winter. Under forced ventilation (gestation and farrowing barns) two axial ventilators were found inside of the barns though their operability was quite minimum.

C. Location of the monitor and input data

The Dust Track Model 8520 Aerosol monitor was positioned approximately at 2 m above the floor level in the center of the pig barn in order to cover the living space of the pigs and the working area of the farmers (See Figure 1).

The data was recorded every half minute (30 seconds) and downloaded every two days during the mornings. Due to the restriction of the number of instruments, PM10, PM2,5 and PM1 were observed alternatively after an interval of two days. The following data was monitored:

- Date of measurement.
- Dust particle concentration: aerodynamic sizes of PM10, PM2,5 and PM1.

The data specified above was processed for 24-hour cycles.

III. RESULTS AND DISCUSSION

Overall, the concentration of inhalable dust (10 µm) was lowest for farrowing pigs while highest for fattening pigs (See Table III). However, the respirable dust (2,5 µm) was highest in farrowing pigs and lowest in gestation pigs (See Table II). Besides, the respirable dust (1 µm) was highest for fattening pigs and lowest for weaning pigs (See Table I).

The current recommendations for continuous exposure of pigs to dust, specify a maximum concentration level of 2,5 mg/m^3 for both inhalable and respirable dust (total dust) and a maximum level of 0,23 mg/m^3 for respirable dust [1].

In effect, the results on this study showed that the respirable dust (2,5 µm and 1 µm) surpassed in most of the cases the threshold values given above. Indeed, fattening and weaning pigs were of main concern (See Tables I and II).

Environmental factors, such as ventilation parameters, feeding practices, bedding materials, manure and wastewater handling can affect dust concentrations and may differ from country to country. For example, typical ventilation systems in pig buildings found in Denmark and the Netherlands are provided with air outlets in the roofs, while in English buildings, air exhausts are typically found through the side walls or end walls. In this study, the Chinese manure management system is denominated gan qing fen in which two fractions are generated, i.e., pig manures collected in a dry basis and wastewaters that flows to the biogas plant. Moreover, windows and doors are mainly open (in most of the cases broken) allowing a high ventilation rate and internal airflow. Such differences between countries will influence on the air flow characteristics, which affect dust distribution [4]. The main results are presented as follows,

TABLE I. RESULTS PM1

Pig Stage	Mean (mg/m^3)	Std. Deviation (mg/m^3)
Gestation	0,25	0,08
Farrowing	0,15	0,06
Weaning	0,35	0,20
Fattening	0,36	0,14

TABLE II. RESULTS PM2,5

Pig Stage	Mean (mg/m^3)	Std. Deviation (mg/m^3)
Gestation	0,21	0,09
Farrowing	0,45	0,12
Weaning	0,29	0,07
Fattening	0,22	0,09

TABLE III. RESULTS PM10

Pig Stage	Mean (mg/m^3)	Std. Deviation (mg/m^3)
Gestation	0,29	0,16
Farrowing	0,46	0,10
Weaning	0,83	0,34
Fattening	0,98	0,47

Figure 1. Dust sampling in a weaning barn with slatted floor.

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