CONCENTRATION OF AIR PARTICULATE MATTER AT CATTLE MARKET IN MUBI, NIGERIA

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Abstract

Determination of the levels of particulate matter in Mubi cattle market was carried out between the months of January to April, 2010. Samples were collected for measurements of particulate matter (PM) of particle diameters of PM_{10}, and $PM_{2.5}$. After gravimetric analysis of weekly measurements, it was found that PM_{10} concentration values ranged between 3067.1 to 5222.3µg/m^3; $PM_{2.5}$ concentration values ranged between 546.12 to 1433µg/m^3. This study was undertaken as preliminary work having in mind that activities in the cattle market could be emitting high levels of particulate matter in the atmosphere, which might be degrading the quality of the air. It was concluded that particulate matter came from three major sources: movement of cattle and people, domestic activities, and traffic emissions due to fuel burning.

Keywords: particulate matter, gravimetric analysis, domestic activities, traffic emission.

Introduction

The activities of nature, including humans, produce a great number of different substances, which are introduced (emitted) into environmental compartments (air, water and soil) causing pollution. The interest in air pollution is related to the fact, that air contains oxygen essential for life, and what is even more important, that is quality has a direct influence on human health due to human basic function such as breathing. Air pollution are considered as substances which change the qualitative composition of air in relation to the called average composition of troposphere; natural components of air (carbon dioxide, nitrogen oxide and methane) appearing at higher levels than results from their contribution in the average composition of troposphere.

Protection against detrimental effects of polluted air should be handled with reliable information on the level at which particular pollutions are present. Such information can be achieved by measurement of the particular substances using proper analytical techniques.

Particulate Matter (PM) refers to all airborne particles, in both the solid and liquid phase (except pure water) ranging in size from approximately $0.005\,\mu m$ to $100\,\mu m$ aerodynamic diameter (AD - diameter of a spherical particle with equal settling velocity and unit density) (CEPA and FPAC 1999). From this vast size range, there are two primary size ranges of particulate matter that are of most interest to regulatory and health agencies. The first, PM10, refers to particulate matter less than $10\,\mu m$ in aerodynamic diameter, the second, PM2.5, refers to particulate matter less than $2.5\,\mu m$ in aerodynamic diameter (Health Canada and Ontario Ministry of Health, 1997).

Suspended particulate matter has the ability to decrease levels of pulmonary lung function in children and adults with obstructive airways disease. It also has the ability to increase in daily prevalence of respiratory symptoms in children and adults; increase in physician and emergency room visits for asthma and other respiratory conditions; increase in hospitalizations for respiratory and cardiac conditions; increase in cardiac and respiratory mortality on days after those with high particulate levels (Rhebergen *et al.* 1999; Johnson 1999). In addition to the health effects, the fine PM has a secondary effect of visibility impairment through a regional haze, and a "soiling" effect, when the particles accumulate on cars, laundry (outside), and homes. This results in a "nuisance impact" on the environment in addition to the health impact (Pacific Environmental Services, Inc. 1999; Rhebergen *et at.* 1999).

Several studies have provided indicative data on exposure to some key particulate matter (Wiech and Raw, 1995, 1996; Berry et al., 1996; Venn et al., 2001, Pfeifer et al, 1991, Adams et al, 2001, Johansson and Johansson, 2002, Chillrud *et al,* 2004).

This study aimed, for the first time, at establishing presence of particulate matter in the atmosphere as a result of activities at cattle market in Mubi, Nigeria. It also focuses on the implications for exposure.

Apart from legal built houses, there are many self-built houses in this place because of the business taking place in the market. Traffic is heavy. It comprises of haulage trucks, commercial vehicles to transport people and cattle from and to Mubi. A major road where all these vehicles pass is about 50 meters, where air sampling was conducted.

Study Area

The study was carried at Mubi cattle market. Mubi is a Nigerian town, located to the northeastern part of the part of the country, in Adamawa state. It was once a constituent of the German Territory of Northern Cameroon. The town lies on latitude $10^0 16'$ and longitude $13^0 16'$. Mubi town was the provincial capital of the erstwhile Sardauna province. The town is situated at the foot of the Mandara Mountains separating Nigeria from the Republic of Cameroon and on the western banks of the river Yedseram. This river flows north into Lake Chad. The town has a pleasant weather and scenic horizons.

Mubi cattle market is the largest livestock market in the Northeastern part of Nigeria and it is recognized internationally. Cattle, on weekly basis are being brought to the Mubi cattle market from neighbouring villages as well as from the republics of Cameroon, Chad and Niger. On each Mubi cattle market day, that is every Tuesday, an average of 30 to 35 trailer trucks of cattle are being sold and transported to the Southern part of the country.

Materials and Methods

A Staplex Model TFIA-2 High Volume Air Sampler was used for air sampling (Figure 1). The Staplex High Volume Air Sampler consists of the main sampler unit with an indirect orifice flow meter mounted to the rear exhaust plate and a 4 inch (10.14 cm) diameter filter holder assembly. (Other size filter holder assemblies are available, including the SH810 8" x 10" Filter Holder Assembly) Additional 4 inch diameter filters holder assemblies Part No. SH4 are available to allow fast and convenient filter changes, minimizing filter handling in the field.). The High Volume Air Sampler is designed to draw air through a filter after weighing at flow rates up to 2 cubic meters per minute (CMM) [70 cubic feet per minute (CFM)].Weighing was done using a Shimadzu model AY220 laboratory weigh balance. The sampler collects particles with aerodynamic diameters of approximately $100\,\mu m$ or less. The samplers mounted at the cattle market site (Figure 2) were used to determine the average ambient total suspended particulate concentrations over the sampling periods.

Measurements of PM_{10} and $PM_{2.5}$ fractions of particulate matter were carried out using two different Staplex Model TFIA-2 High Volume Air Sampler – one contains a fine filter (for particles with aerodynamic diameter $d_{ae} \leq 2.5\mu m$) and the other a coarse filter (for particles with aerodynamic diameter $2.5\mu m \leq d_{ae} \leq 10\mu m$). The sampling times recorded with Model DTM-4CDT Time, were between 9 and 10 *h* depending on the time the samplers were stopped. After sampling, the filters were folded in half lengthwise so that only surfaces with the collected particulate matter were in contact and placed in a re-sealable bag and pre-conditioned for 24 h before reweighing to determine the particulate matter weight deposited on the filter. In all, 16 samples of both fractions were collected during the campaign over a period of 4 months. All the samples were collected during the market days, at least once a week. The sampling was done for same location at the same fixed point throughout the sampling periods. Concentration of particulate matter was then calculated.

Figure 1: Air samplers involved during the sampling displayed in Physics Laboratory in Adamawa State University, Mubi

Figure 2: One of the samplers mounted at the cattle market during operation.

Theoretical Analysis

Particles suspended in air react to drag, gravitational and buoyant forces according to their density, shape, roughness, orientation and rotation (or spin). Their reaction to body forces is also related to the properties and dynamic characteristics of the air in which they are suspended.

Complicating the matter further, ambient particulate matter consists of a wide range of particle sizes, materials and shapes. Consequently, the empirically derived aerodynamic parameters must be measured for the ensemble of particles, representing some kind of average of the aerodynamic parameters of the individual particles. The manner in which the individual parameters are averaged (in the empirical sense) depends heavily on the experimental apparatus used and the fluid dynamics characteristic of the apparatus in its designed range of operation.

There are several urban diffusion models to determine space and time variation of pollutants (Degrazia and Moraes, 1989; Munuzuri, 1998; Souto et al, 1998). A recommended Gaussian model is used to calculate the concentration of particulate matter originated from continuous emissions from sources located high aboveground level. The basic equation involved in the evaluation of ground-level C concentration of particulate matter at a receptor is given by:

$$C = \frac{Q}{2\pi u \sigma_y \sigma_z} \exp(-\frac{y^2}{2\sigma_y^2}) \left[\exp - \frac{(z-h)^2}{2\sigma_z^2} + \exp - \frac{(z+h)^2}{2\sigma_z^2} \right] \quad (1)$$

where Q represents the source potential and h is the actual height of the source of emission, σ_y and σ_z dispersion parameters are the standard deviations of plume concentration in the horizontal and vertical directions, respectively; z is receptor height, u wind speed and y crosswind distance. The diffusion coefficients σ_y and σ_z were calculated as prescribed by Briggs (1969).

Gravimetrically, the concentration C of particulate matter can be deducted as follows: The mass m of the particulate matter collected on a filter paper is given as

$$m = (m_{post} - m_{pre}) x 10^3 \quad (2)$$

Where m_{post} is post-sampling filter mass in mg, m_{pre} is pre-sampling filter mass in mg and 10^3 is the unit conversion factor for milligram (mg) to microgram (μg).

Particulate matter samplers are required to provide measurement of the total volume of ambient air passing through the sampler V in cubic meters (m^3) at the actual temperatures and pressures measured during the sampling. Use the following formula if V is not available directly from the sampler:

$$V = Q_{av} x t x 10^{-3} \quad (3)$$

Where Q_{av} is the average flow rate over the entire duration of the sampling period (l/m), t is the duration of sampling period (min) and 10^{-3} is the unit conversion factor for liters (l) into cubic meters (m^3).

The ambient particulate concentration in $\mu g/m^3$ can finally be determined by the equation outlined below

$$C = \frac{m}{V} \quad (4)$$

To perform these calculations, both the field data and filter masses must be recorded in the appropriate database tables. The filter masses are captured directly from the balance as described in the materials and methods. Recording the field data in the database includes both importing data files from the samplers and hand entering information that is recorded on the field sheets

Results and Discussion

Table 1 show the data of particulate matter at different sampling days at Mubi cattle market. Results obtained from sampling show that, particulate matter (PM) values recorded during measurements ranged from 546.12 to 5222.3µg/m^3. The mass concentration levels ranged from 546.12 to 1433µg/m^3 for $PM_{2.5}$ and 3067.1 to 5222.3µg/m^3 for PM_{10} as shown in Figure 3.

The lowest concentration levels of 546.12 and 3067.1 μg/m^3 for $PM_{2.5}$ and PM_{10}, respectively were observed on 13th April, 2010 and 2nd February, 2010 while the highest concentrations of 1433 and 5222.3 μg/m^3 for $PM_{2.5}$and PM_{10}, respectively were observed on 9th March, 2010 and 19th January, 2010.

The suspended particulate matter (SPM) at the sampling site was also higher than the ambient air quality standard of 250μg/m^3 set by the Nigerian Federal Environmental Protection Agency.

The high values of $PM_{2.5}$, and PM_{10}recorded could be as a result of dust particles evolved due to the movements of cattle and people within the market during transactions as well as offloading and on loading cattle out of and into the trailer as shown in Figure 4. Domestic activities could also be contributing factors. Domestic activities include the burning of wood for purposes of cooking and the burning of Plant chaff, pod, cob etc to acquire smoke to waive away parasites and flies from disturbing cattle. This emits particulate matter into the atmosphere.

Table 1: Data of particulate matter at different sampling days

Day	*Mass of PM (mg)*		*Total Sucked Vol. (m^3)*		*Concentration (μg/m^3)*	
	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
05/01/10	5894.6	1378.5	1201	1180	4908.1	1168.2
12/01/10	4984.9	1095.0	1185	1162	4206.7	942.3
19/01/10	6225.0	975.4	1192	1184	5222.3	823.8
26/01/10	5121.2	1125.3	1178	1171	4347.4	960.97
02/02/10	4784.6	1083.6	1156	1150	3067.1	942.3
09/02/10	5240.8	767.2	1217	1211	4306.3	633.5
16/02/10	3931.6	886.9	1209	1201	3251.9	738.5
23/02/10	5104.9	1266.6	1187	1179	4300.7	1074.3
02/03/10	5848.7	1298.1	1207	1196	4845.7	1085.4
09/03/10	6014.9	1673.7	1175	1168	5119.1	1433.0
16/03/10	5491.2	773.0	1212	1207	4530.7	640.4
23/03/10	4504.2	777.6	1221	1219	3688.9	637.9
30/03/10	4668.1	1157.1	1171	1167	3986.4	991.5
06/04/10	3731.9	1087.8	1143	1138	3265.0	955.9
13/04/10	4027.9	660.8	1215	1210	3315.1	546.12
20/04/10	4765.6	695.2	1203	1197	3961.4	580.8
27/04/10	3547.2	920.5	1134	1129	3128.0	815.3

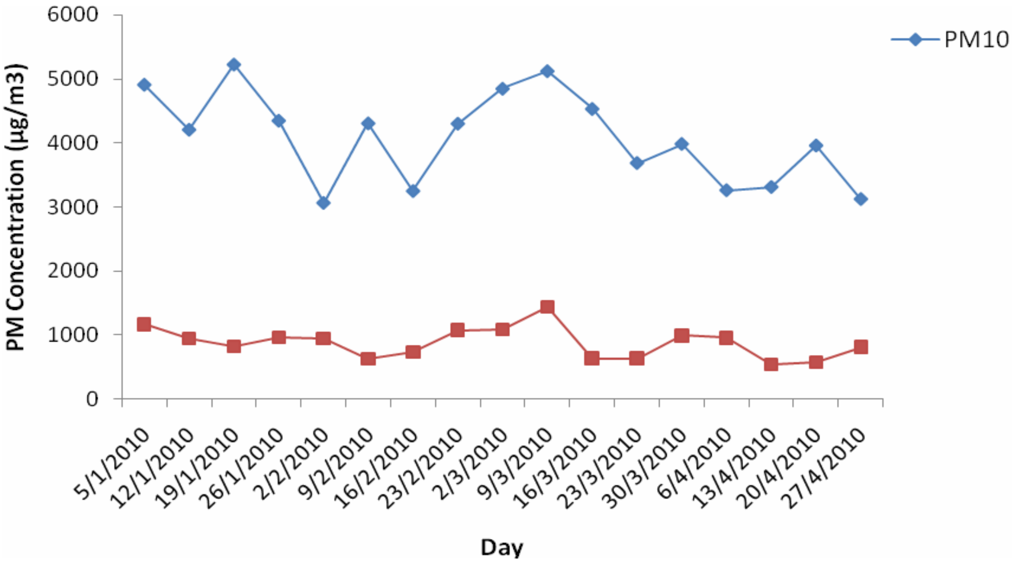

Figure 3: The ambient particulate concentration of $PM_{2.5}$ and PM_{10} particles

The recorded particulate matter values mentioned above could also be a contribution from transport emissions. There is a busy un-tarred road some 50 meters from the study site where sampling was done (Figure 5). This road is use by commercial vehicles to transport people and cattle from and to the market, trailer trucks for the purpose of transporting cattle from the market and to the market, as well as private cars. Vehicles emit particulate matter in the atmosphere during combustion of gasoline.

The two particulate fractions are inhalable and the $PM_{2.5}$ fractions are particularly respirable, and are therefore likely to get into the respiratory system and get absorbed into the blood. Particulate matter provokes respiratory diseases and can cause cancer, corrosion, destruction to plant life etc. They can also constitute a nuisance to interfere with sunlight to form smog and haze and also to act as catalytic surfaces for reaction of adsorbed chemicals.

Conclusion

This study has shown the extent of air particulate pollution in the cattle market place in Mubi, Nigeria. It was undertaken as preliminary work having in mind that, activities in cattle market could be emitting high levels of particulate matter in the atmosphere which might be degrading the quality of the air. The particulate concentrations were found gravimetrically, in the range of 546.12μgm^{-3} and 5222.3μgm^{-3}. It was observed, however, that the weekly particulate matter especially of PM_{10} emitted were quite high when compared to particulate matter of diameter 2.5 microns. The duration during which individuals are exposed to particulate matter may be a better predictor of long-term lung damage. It was concluded that particulate matter came from three major sources: movement of cattle and people, domestic activities, and traffic emissions due to fuel burning.

Figure 4: On loading of trailer with cattle at the market.

Figure 5: Commercial vehicles on their way from and to the market.

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