

Sampling of respirable particle PM₁₀ in the library at the Metropolitana University, Campus Azcapotzalco, Mexico City

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Abstract

This study presents the results of a sampling campaign of PM₁₀ respirable particles, carried out at the library located in the Metropolitana University, Campus Azcapotzalco, through seven months: March, April, May, June, July, September and October, 2005. We collected a total of 84 samples, considering only the three main levels of the Library and selecting a total of nine sampling points. The other levels are located at the mezzanine and the main entrance, where there is no rug and the floor is cleaned up daily with a wet cloth. Samplings were carried out for nine weeks, three weeks for each level, so finally, we ended up with 18 samples for level 1, 27 for level 2, and 36 for level 3; plus three reference samples. Samples were collected using a set of sampling pumps SKC for indoor sampling, from 10:00 a.m. to 6:00 p.m. on Monday, Wednesday, and Friday. Three reference samples were collected on Thursday, when there is less activity in the Library. In level 1, where there is a study area, the minimum mass concentration of R.P. was 15.27 µg/m³. This area has no rug and it is near the main entrance. The maximum mass concentration of R.P. was 131.94 µg/m³ for the same level, in a sampling point located in a corner far from the entrance. For level 2, the minimum concentration of R.P. was 8.33 µg/m³, on the shelves T-J, and the maximum concentration of R.P. was 157.77 µg/m³, on the shelf Q. This difference in concentration between the two sampling points could have been originated due to the type of books on the shelves, which are demanded more by the students. It is important to point out that this level has an old rug. In level 3, the minimum concentration of R.P. detected was 6.94 µg/m³, in the sampling point of the F shelf, and the maximum concentration, on the shelves H-T, was 197.22 µg/m³. The difference in concentrations may be due to the subjects of the books on each shelf and the interest of students for those books - so there are more people going in and out - also, in this level there is an old rug that is usually cleaned using a vacuum cleaner, but not very often. This type of cleaning is the same for level 2. It is important to point out that the library building does not have any air conditioning or air movers.

Keywords: indoor air pollution, respirable particles, library indoor air pollution.



1 Introduction

Describing indoor air quality is not a simple thing to do. It is a constantly changing interaction of complex factors that affect the types, levels, and importance of pollutants in indoor environments. These factors include: sources of pollutants or odors; design, maintenance, and operation of building ventilation systems; moisture and humidity; and occupant perceptions and susceptibilities. In addition, there are many other factors that affect comfort or perception of indoor air quality [7].

The rate at which outdoor air replaces indoor air is described as the air exchange rate. When there is little infiltration, natural ventilation, or mechanical ventilation, the air exchange rate is low and pollutant levels can increase [8].

Inadequate ventilation can increase indoor pollutant levels by not bringing in enough outdoor air to dilute emissions from indoor sources and by not carrying indoor air pollutants out of the building. High temperature and humidity levels can also increase concentrations of some pollutants [8].

Immediate effects may show up after a single exposure or repeated exposures. These include irritation of the eyes, nose, and throat, headaches, dizziness, and fatigue. Such immediate effects are usually short-term and treatable. Sometimes the treatment is simply eliminating the person's exposure to the source of the pollution, if it can be identified. Symptoms of some diseases, including asthma, hypersensitivity pneumonitis, and humidifier fever, may also show up soon after exposure to some indoor air pollutants. [8].

Typically, indoor $PM_{2.5}$ consists of ambient (outdoor) particles that have infiltrated indoors, particles emitted indoors (primary), and particles formed indoors (secondary) from precursors emitted both indoors and outdoors [1].

Fine particles smaller than $2.5\ \mu m$ in aerodynamic diameter ($PM_{2.5}$) are of the greatest concern owing to their size and transportability in the human body [2].

In the present project, samplings of respirable particles were made at the inside of the library of the Metropolitana University - Campus Azcapotzalco, on all the three levels, during a school trimester. The results concluded by this research will be used to suggest changes at the interior of the library, such as: getting rid of the rugs, open new spaces for ventilation, and installing or replacing air extraction equipments -among other proposals- in order to improve the inside ambience of the building and to prevent health problems of users and library staff.

2 Methodology

2.1 Selection of sampling points

The sampling points were chosen after a careful inspection of the facilities of the library in the Metropolitana University, aimed at making a qualitative evaluation of the place, identifying the spots with greater activity, and to observe their physical characteristics (like student inflow intensity, the kind of furniture, if there is a rug, ventilation, or whether there are curtains, air currents, etc.).



Keeping all these in mind, it was possible to select the right spots where to place the sampling equipment, preferably on those shelves located at more than 1.5 meters high from the floor.

With that information, it was decided to divide the interior of the Library in three levels: LEVEL 1: with two sample points, LEVEL 2: with three sample points, LEVEL 3, with three sample points, and one sample point at the thesis and internet section; in such a way, as to include the biggest possible area of the Library.

2.2 Library characteristics

The study area has an air conditioning system, which is out of order. In spite of the fact that there are many large windows, they cannot accomplish their function of ventilating, because they cannot be opened; they only work as a source of light. The only ventilation is the one provided by the main entrance.

2.3 Sampling period

The sampling period was established considering certain factors, like: the trimester school term at the Metropolitana University (eleven weeks), the service schedule offered by the Library, and the rush hours, among others. This way, it was decided that the sampling period would be of three months in a row, starting on April the 25th, 2005, and finishing on July the 15th, in the same year. There was a three week sampling period made for each level.

During the nine-week sampling period, samples were taken every three days, on Mondays, Wednesdays, and Fridays, and each sample-taking lasted eight hours - at rush hours - from 10:00 AM to 18:00 PM.

3 Analysis

A gravimetric analysis was made to the filters. They were conditioned at constant temperature and humidity, before and after the sampling. The weighing of the filters was made with a Cahn Electronic Scale at the Atmospheric Monitoring Direction Lab of Mexico City's Hall.

4 Results and discussion

The selected sampling points for each level were classified and distributed as follows: two in Level 1: PM1 at the section for documentation and PM2 in the study area; three in Level 2: PM3 at the area for rare books, PM4 at the shelf area for books classified as Q, and PM5 at the shelf area for books classified as JT; four in Level 3: PM6 at the shelf area for books classified as HD, PM7 at the shelf area for books classified as HT, PM8 at the shelf area for books classified as F, and PM9 at the shelf area for books classified as PQ. It is important to point out that Levels 2 and 3 have a rug and they do not get an adequate cleaning. This nomenclature for the sampling points will be used from now on at the forthcoming discussion of results.



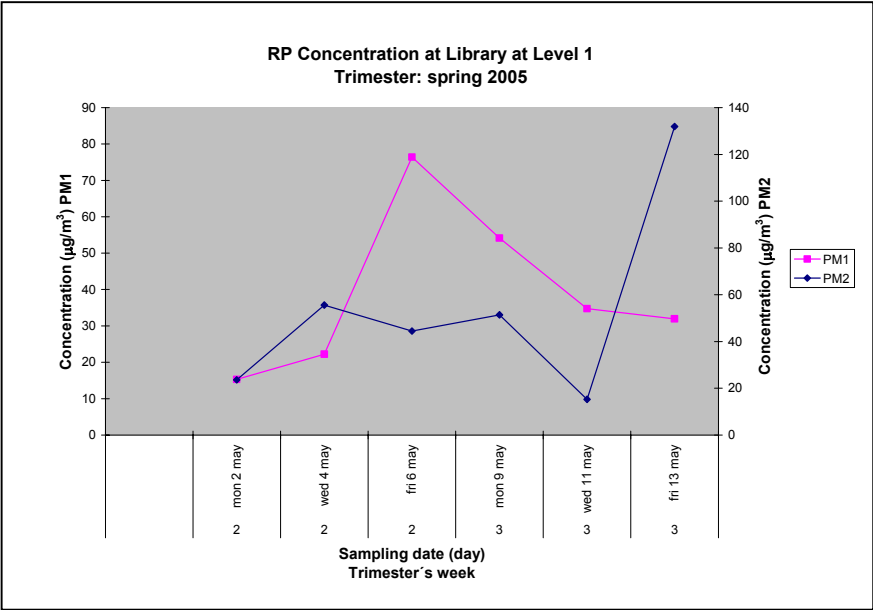


Figure 1: Concentration of respirable particles (RP) at library level I.

The maximum concentration of RP at Level 1 in the Library was measured at both sampling points on a Friday. Point PM1, located in the section for documentation, got a value of $76.9 \mu\text{g}/\text{m}^3$, in the second week of the trimester. This RP concentration is low, what reflects the activity at this time of the school term, since students are only starting to attend the library. For point PM2, located at the study area, the maximum concentration value of RP was $131.94 \mu\text{g}/\text{m}^3$, measured at the third week of the trimester. The RP concentration value is bigger than the previous week because of the increase of students visiting the library, since they are getting ready for their first partial exam then. The minimum value for both points matches with those registered on Wednesday, during the second week. As it can be seen in Figure 1, they got a value of $15.28 \mu\text{g}/\text{m}^3$.

The maximum RP concentrations for sampling points PM3 and PM5 were measured on a Friday. At PM3, located in the shelf area for rare books, the value obtained was $125 \mu\text{g}/\text{m}^3$, during the fifth week of the school term. The value registered for PM5, located in the JT bookshelf area, was $116.67 \mu\text{g}/\text{m}^3$, in the sixth week of the trimester. The maximum concentration at PM4, located in the Q bookshelf area, was $152.78 \mu\text{g}/\text{m}^3$, in the seventh week of the trimester, on Monday. These results match the activities of the school term, since the second partial exam takes place at this time, and lots of students come to the library to get ready for their test in these weeks. The minimum concentrations for the Q (PM4) and JT (PM5) bookshelf areas were measured on a Wednesday, registering $69.44 \mu\text{g}/\text{m}^3$ at PM4 and $12.50 \mu\text{g}/\text{m}^3$ at PM5. For the rare books

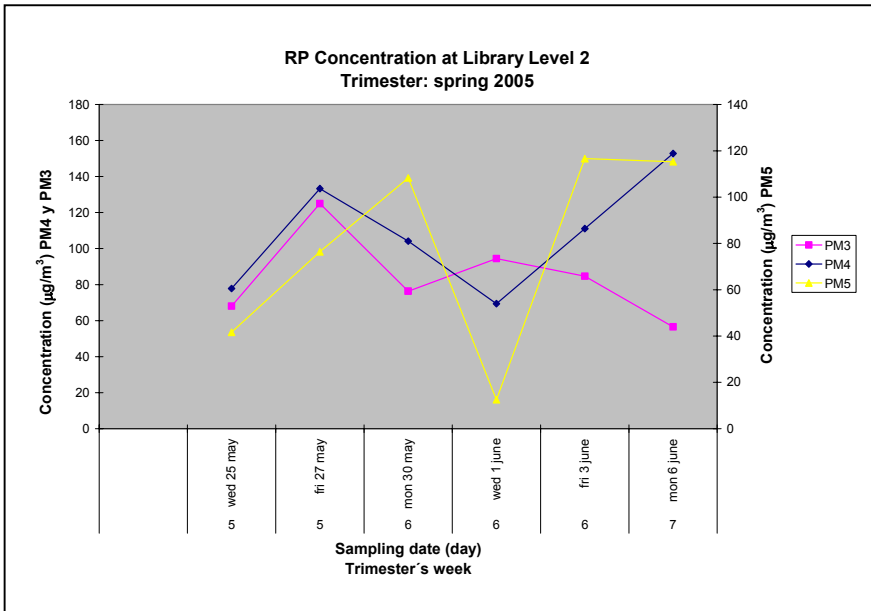


Figure 2: Concentration of respirable particles (RP) at library level 2.

shelf area (PM3), the minimum concentration was $56.50 \mu\text{g}/\text{m}^3$ and it was registered on a Monday (see Figure 2). It is important to point out that the concentration values at the different sampling points also show the shifts in the demand for the different kinds of books located on different shelves. In general, the books located in Level 1 are theses; in Level 2, related to Basic Science and Engineering; and in Level 3, Social Science and Arts.

The maximum RP concentration at sampling points PM6, PM7, PM8, and PM9, was registered during the tenth week of the school term, on Wednesday. The concentration obtained for PM6, located in the HD bookshelf area, was $156.94 \mu\text{g}/\text{m}^3$. For PM7, located at the HT bookshelf area, the value registered was $197.22 \mu\text{g}/\text{m}^3$. For PM8, placed at the F book shelf area, was $184.72 \mu\text{g}/\text{m}^3$, and for PM9, located in the PQ book shelf area, was $200 \mu\text{g}/\text{m}^3$, being the latter the highest registered during the whole sampling period.

The concentrations obtained at this stage of the sampling period were the highest registered by the present study, and match the school activities, since the three-month academic calendar schedules the third partial exam at the eleventh week. Thus, the Library is visited by a large amount of students from the Campus at this time, and most of them ask to borrow the books to take home, anticipating the final exams (global evaluations) scheduled for the twelfth week of the school term.

The minimum concentration for all the sampling points at this Level took place on a Wednesday, with the difference that for points PM6, PM7, and PM8, it occurred at the eighth week; while for PM9, at the seventh. The minimum RP

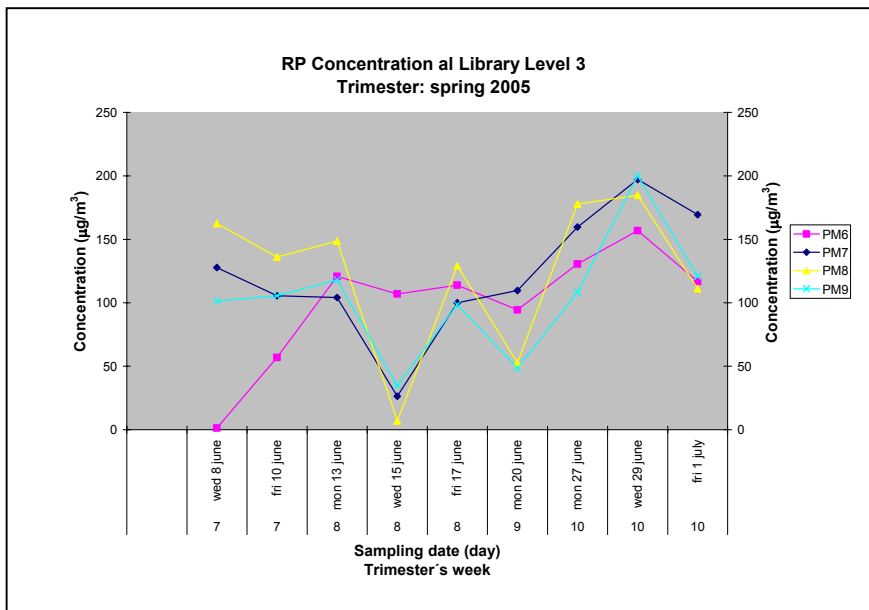


Figure 3: Concentration of respirable particles (RP) at library level 3.

concentration value measured at PM6 was $1.38 \mu\text{g}/\text{m}^3$, and we have to draw attention to the fact that this was the lowest registered in all the sampling period. This particular point was located at an area that had no air currents. The values for the minimum concentrations at all the other sampling points were: $26.39 \mu\text{g}/\text{m}^3$, at PM7, $6.94 \mu\text{g}/\text{m}^3$, at PM8, and $34.72 \mu\text{g}/\text{m}^3$, at point PM9 (see Figure 3).

The minimum concentration at all the sampling points in this Level took place on a Wednesday. The difference is that for points PM6, PM7, and PM8, it occurred at the eighth week; while for PM9, at the seventh. The minimum RP concentration registered for PM6 was $1.38 \mu\text{g}/\text{m}^3$. It is important to point out that this is the lowest concentration registered throughout all the sampling period, and that this particular point was located in a place where there are no air currents. The minimum concentration values for all the other sampling points were: $26.39 \mu\text{g}/\text{m}^3$ at PM7, $6.94 \mu\text{g}/\text{m}^3$ at PM8, and $34.72 \mu\text{g}/\text{m}^3$ at point PM9 (see Figure 3).

5 Conclusions

As it can be seen in the Results, the maximum RP concentration in Level 1 was $131.94 \mu\text{g}/\text{m}^3$, measured in the study area on Friday, May 13th, 2005; while the minimum RP concentration was $15.28 \mu\text{g}/\text{m}^3$, registered at the area for documentation, on Monday, May the 2nd, 2005.

Based on the results obtained throughout all the sampling period, we can assume that, since there is no carpet in this Level, the RP have no place where to deposit and accumulate, adding up the fact that the main entrance provides an air current that makes it possible to force the RP out of the library.

In Level 2, the maximum concentration was $152.78 \mu\text{g}/\text{m}^3$, reported at the Q bookshelf area, on Monday, June the 6th, 2005. The minimum concentration was $12.50 \mu\text{g}/\text{m}^3$, registered at the JT bookshelf area, on Wednesday, June 1st, 2005. The maximum concentration value in this Level is higher than in Level 1. This may be because it has a carpet, what gives the RP a place where to deposit and accumulate. Also, it lacks adequate ventilation that could force them out or disperse their concentration in the air inside. It is also necessary to consider that there is a high attendance of students to this Level, what makes the RP deposited on the rug be re-suspended in the air.

In Level 3, the maximum RP concentration was $200 \mu\text{g}/\text{m}^3$, registered at PQ bookshelf area on Wednesday, June 29, 2005. The minimum concentration was $1.38 \mu\text{g}/\text{m}^3$, reported at the HD bookshelf area, on Wednesday, June the 8th, 2005. It is important to consider that, besides having a rug, there are no air currents in this Level, and that the activity in the library is increasing at this time, because students are preparing their final exams; what makes the end of the school term.

The maximum RP concentration registered in the Library during the whole sampling period was reported in Level 3 ($200 \mu\text{g}/\text{m}^3$). We assume that this high RP concentration is produced by an accumulation of dust as a result of the bad cleaning of rugs, and because there are no air currents in this level that can provide adequate ventilation.

6 Recommendations

- To include a ventilation system capable of providing enough oxygen and to disperse the pollutants at the inside of the occupied spaces (dispersing of polluting particles emissions at the source).
- To do the cleaning of clothed furniture and rugs by means of a vacuum cleaner.
- To do the cleaning at a time when there is no personnel, neither users, present at the library.
- If possible, to get rid of the rugs and replace them with some other economical and easy to clean kind of floor.
- To replace the clothed furniture with a plastic one, to avoid dust accumulation.
- To avoid using ammonia-based cleaners and/or germicides, which contribute to Volatile Organic Compounds (VOCs).
- To use air deodorants, wax for furniture, or paint, the least as possible, since they are considered toxic aerosols.
- If the rug is not replaced, the cleaning should be done more frequently.



- In the case that a ventilation system cannot be acquired, we suggest to, at least, open a window at each Level, so that an air current can come through.

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