ANALYSES OF HUMAN EXPOSURE TO URBAN AIR QUALITY IN A CHILDREN POPULATION

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INTRODUCTION

The association between particulate matter (PM) and health effects, particularly in vulnerable populations such as children, have been shown in several studies. In general this studies use outdoor concentrations to show this relationship, in spite of most people spend about 90% of their time indoors (Koening, J., 2005). Children spend a significant time of the day in school where the air is replete with a variety of air pollutants including PM. Indoor PM is a combination of indoor generated particle and outdoor penetration due to many building and environmental factors, such as air-exchange rate, infiltration factor, type of indoor activities, outdoor air pollution, PM diameter, etc. This study intends to correlate indoor and outdoor PM with less than 10µm diameter (PM_{10}) concentration, using modelling and measurements and study human exposure to urban air pollution levels in a children population.

METHODS

To characterize children exposure to air pollutants, outdoor and indoor PM_{10} were measured and modelled.

Indoor PM_{10} concentrations were hourly measured by a Beta Gauge Dust Monitor in two schools in Setúbal district, Portugal, for a week period each. These schools were chosen because they have a monitoring station outdoor the classrooms, which permit to relate indoor and outdoor PM_{10} concentration in the same temporal time period. The inlet of indoor PM_{10} measurement equipment was 2m above the floor in the middle of the classroom. All the activities developed in the classrooms were recorded by sort of activity: class, cleaning, administrative work, open windows, etc; as well as activity start and end hour. At measures period, in the 1^{st} classroom, only administrative work and open windows were carried out, as we can see resumed in *Table 1*. The 2^{nd} classroom is deactivated. Classrooms characterization was also considered (*Table 2*). None of the classrooms has air conditioner.

Table 1. Developed Activities

Activity		Date	Period
Nº open windows	2	07/07/2005	4:10 p.m.-6:00 p.m.
	2	08/07/2005	1:09 p.m.-6:45 p.m.
	4	11/07/2005	11.30 a.m.-3.00 p.m.
Administrative work		07/07/2005	4:10 p.m.-6:00 p.m.
		08/07/2005	1:09 p.m.-1:30 p.m. and 3:45 p.m.-6:45p.m.
		11/07/2005	11.30 a.m.-3.00 p.m.

Table 2. Classroom characteristics

	Vol. (m^3)	no. windows	Windows area (m^2)	Windows direction	Windows protections	Floor type	Furniture
1^{st} Classroom	164	7	2	NW/NE	Blind	Wood	Wood
2^{nd} Classroom	258	6	2.5	W	Blind	Mosaic	Wood

Outdoor PM_{10} concentrations and meteorological data were provided by Comissão de Coordenação e Desenvolvimento Regional de Lisboa e Vale do Tejo (CCDR-LVT), who manage the air quality monitoring stations on the region, for the same time period of indoor measurements. These stations have an equipment with the same method as the one used indoor. This data permits us to establish a correlation between indoor and outdoor PM_{10} concentration, and deduce how outdoor pollution interfere in the air quality indoor.

The influence of human exposure to air quality in children health was analysed using data of paediatric population with respiratory problems observed in Barreiro city's hospital in the same period, plus three days, of the measurements.

ADMS-Urban was used to simulate outdoor air quality in others schools in Barreiro city. These simulation works permit to establish a relation between PM_{10} concentration and hospital admissions. PM_{10} outdoor concentration measurements also allowed the evaluation of models performance.

RESULTS AND DISCUSSION

Since indoor activities influence classroom PM_{10} concentration, the measurements were separated by weekend (Friday-Sunday) and weekday (Monday-Friday), daytime with activity and daytime without activity, day (8h a.m.-8h p.m.) and night (8h p.m.-8h a.m.). *Table 3* shows statistical results of measurements in 1st Classroom.

Table 3. Average, median, average ratio (I/O) and correlation between indoor/outdoor in 1st Classroom

	Average		Median		I/O ratio average	Correlation
	Indoor	Outdoor	Indoor	Outdoor		
Weekend	23.26	48.12	24.42	44.12	0.55	-0.20
Weekday	22.03	47.24	17.76	46.20	0.52	0.57
Day	23.28	47.47	18.87	47.18	0.58	0.45
Night	21.47	47.52	18.87	43.29	0.49	0.49
Activity Days	25.11	51.09	19.98	51.06	0.69	0.34

In spite of the 2nd Classroom deactivation, the same separation was made to compare the results of the two classrooms. The results are in *Table 4.*

Table 4. Average, median, average ratio (I/O) and correlation between indoor/outdoor in 2nd Classroom

	Average		Median		I/O ratio average	Correlation
	Indoor	Outdoor	Indoor	Outdoor		
Weekend	14.57	18.93	14.43	19.70	0.74	0.91
Weekday	21.94	29.24	17.21	22.06	0.80	0.63
Day	21.05	29.20	17.21	22.06	0.78	0.91
Night	19.67	27.15	14.43	19.98	0.77	0.95

Analysing the 1st Classroom results, it can be seen that statistical results are similar considering the chosen separation. The activity days show a slight increase, as expected, due to the indoor sources like PM_{10} re-suspension and open widows which permits outdoor PM penetration. The activity period also increase I/O ratio, exceeding in some hours the value one which indicates the stronger influence of indoor sources. The fact of most of I/O results are smaller than one, indicates that transport of PM from outdoor to indoor is more important than indoor sources. At night the value is smaller as result of low or none activity indoor and outdoor. The correlation between indoor and outdoor PM_{10} was negative on weekends and highest during weekday. On weekend outdoor activities are different from weekdays, there's no rush hour and there's outdoor activity distributed over the day. In a classroom indoor activities are none. That difference can explain a great variation of outdoor PM_{10} concentration with consequent negative correlation with indoor concentration. Nevertheless, on weekend, when the concentration increases in outdoor increases also indoor but soften (*Fig. 1*).

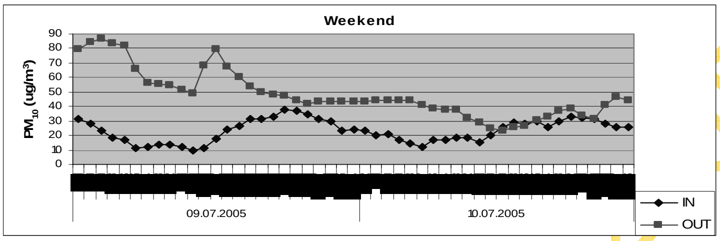

Fig. 22; Outdoor and indoor concentration on weekend, 1st Classroom

Comparing data in activity days when windows are open, in spite of the low correlation, it can be seen the increase on indoor PM_{10} concentration (*Table 1 and Fig. 2*). This increase results from a greater permeability of the building and from the rising of the indoor sources contribution which are responsible for the lowest correlation.

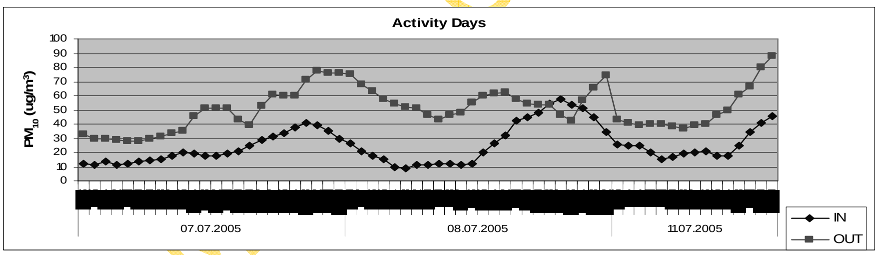

Fig. 2; Outdoor and indoor concentration on Activity days, 1st Classroom

PM concentrations in the 2nd Classroom are lower than in 1st Classroom, both indoor and outdoor, representing a smaller outdoor activity near the 2nd Classroom. In this case weekend and nights have smaller concentrations, which indicate that in this area the weekdays are busier. The higher correlation between indoor and outdoor reflects a high permeability of the building, since there's no activity in this classroom and PM_{10} indoor concentration follows outdoor concentration, all PM_{10} inside the classroom comes from outside (*Fig. 3*).

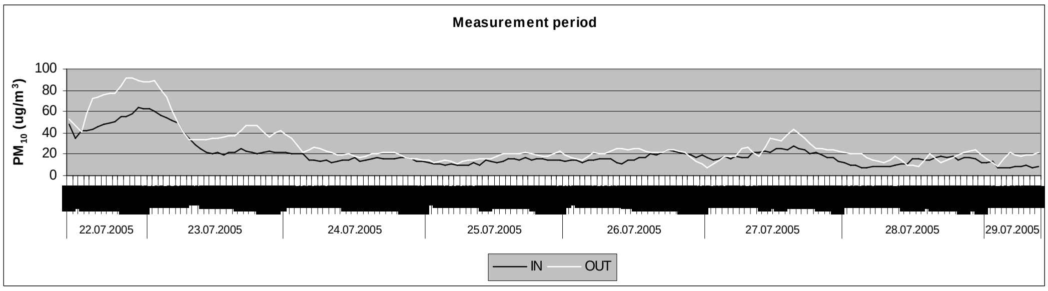

Fig. 3; Outdoor and indoor concentration in the measurement period, 2nd Classroom

The analyses results of human exposure to urban air quality were inconclusive. This relation is not easy to predict due to a large number of variables which are being study for further conclusions.

ADMS-Urban was used to simulate outdoor air quality in others schools in Barreiro city, in most frequent meteorological conditions. With this simulation work it's possible to verify which schools are more affected by outdoor air pollution (*Fig. 4*).

(a) (b)

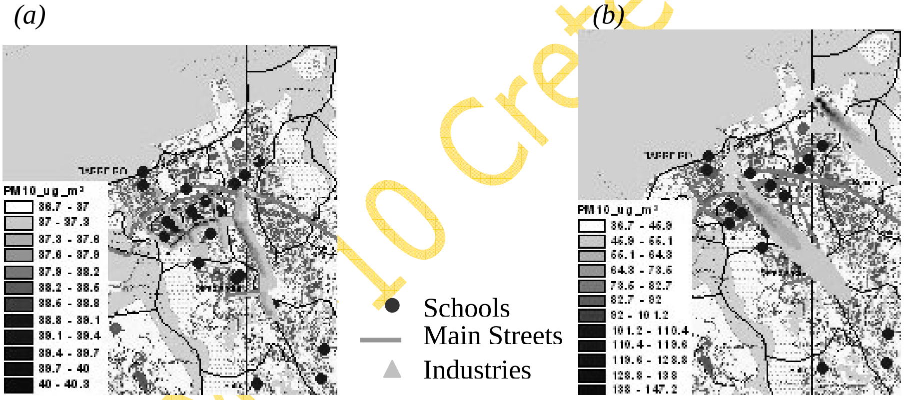

Fig. 4; Outdoor concentration and dispersion of PM_{10} from traffic (a) and from industry (b)

CONCLUSION

Indoor activities have a great influence in indoor PM generation. Almost every human activity generates PM, from re-suspension just by walking in the room to open windows which permits the entrance of outdoor PM.

This study results showed, on the whole, a positive correlation between indoor and outdoor PM concentrations, whatever the building permeability. However the 2nd Classroom building have a greater permeability to the outdoor sources, which can represent a bigger risk to this children population, since they are more exposed to air pollution.

In activity days in the 1st Classroom, some indoor/outdoor PM_{10} ratio (I/O) values exceed the unit, which permit to conclude about the bigger influence of indoor PM generation. When no activities were developed in this classroom, I/O values were lower than one, indicating that the building provides good protection from outdoor sources, protecting the children inside. Nevertheless, this school is near the industrial zone which causes a greater PM_{10} outdoor concentration, therefore is important to provide the classrooms with air conditioner to avoid PM_{10} outdoor penetration by open windows.

The study of the relation between children who attends the urgency of city hospital with respiratory problems and outdoor PM_{10} concentration is being made since September 2003. Since this relation has been inconclusive the work team decided to study human exposition to indoor PM_{10}. In spite of this analyses results were also inconclusive, it is important to continue this study, by following a children sample with respiratory problems, not only the urgency cases, continue the evaluation of indoor and outdoor PM_{10} relation and study children surrounding environmental to evaluate the influence of pollutants in asthma episodes.

Since, it was shown the influence of outdoor sources in indoor PM_{10} concentration, the simulation of outdoor PM_{10} concentration and distribution is important to study the pollutants behaviour in specific meteorological conditions. These results can be used to know the most affected schools and study this children population. Simulation can also be used to alert the authorities when PM concentrations prediction exceed or are near the legal limits, so they can take steps to protect the population in risk.

ACKNOWLEDGENTS
This work was performed in the framework of the POCTI program financed by the FCT (Fundação para a Ciencia e Tecnologia of Portugal) and FEDER program, this project has the reference POCTI/MGS/47247/2002. The authors also wish to acknowledge Comissão de Coordenação e Desenvolvimento Regional de Lisboa e Vale do Tejo (CCDR-LVT), Instituto de Metereologia (IM) and Instituto Geográfico Português (IGEO) by the information provided.

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