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PARTICLE EMISSION IN PAPER PRINTING FACILITY IN LA ROCHELLE

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Abstract. ***Problem statement***. Printing services are known to release multiple pollutants of different sizes during the different processes of printing, gluing and cutting paper. ***The purpose of this article*** was the quantification of pollutant indoor emissions during working shifts in printing service. Particle concentration measurement when three printings are operating continuously showed that values of PM10 and PM2.5 could exceed the limits set by the World Health Organisation (WHO). ***Conclusion***. Measurements in confined environments containing printer and the gluing machine have shown that concentrations can reach values above the limits set by WHO and worrying values in the case of gluing machine. The result affirms the importance of ventilation system and the necessity of dispersing machines in a large.

Keywords: *particule pollution; environmental quality; health risk; air quality standards; printers; cutting paper machines; gluing machines*

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Анотація. ***Постановка проблеми.*** Відомо, що підприємства поліграфічних послуг викидають в навколишнє середовище численні забруднюючі речовини під час різних процесів друку, склеювання та різання паперу. Тому все більше працівників друкарської галузі скаржаться на проблеми зі здоров'ям, які виникають внаслідок впливу механізмів. ***Метою*** даного дослідження було кількісне визначення викидів забруднюючих речовин в приміщенні під час робочих змін у поліграфічній галузі. ***Методика.*** Дослідження проведені на поліграфічному підприємстві, розташованому в місті Ля-Рошель. Вимірювання проводились в різних приміщеннях-секціях, що містять принтери, ріжучі паперові машини, склеювальні машини, та в складських приміщеннях. Проведення вибірки проводилося у трьох секціях об'єкта: дві секції містять друкарські та склеювальні машини, третя − на стійці реєстрації. Вибірка концентрації частинок проводилася з використанням оптичного лічильника Grimm із проміжком часу для відбору проб 1 хв. Під час вимірювань двері між різними ділянками об'єкта залишалися відкритими. Вимірювання концентрації частинок, коли три друкарські машини працюють постійно, показало, що значення кількості частинок PM10 і PM2,5 можуть перевищувати нормативні обмеження, встановлені Всесвітньою організацією охорони здоров'я. ***Висновок.*** Вимірювання в закритих приміщеннях, де розташовані принтер і склеювальна машина, показали, що концентрації частинок в повітрі можуть досягати значень вищих, ніж встановлено стандартами, і тривожних значень у випадку склеювальної машини. Результат підтверджує важливість системи вентиляції та необхідність диспергування машин у великих розмірах.

Ключові слова: *забруднення повітря; якість навколишнього середовища; ризик для здоров'я; стандарти якості повітря; принтери; машини для різання паперу; склеювальна машина*

Introduction. Indoor air pollution in workplaces has become a major concern in recent years as it can have a harmful effect on human health [1−3]. Indoor air pollution is also important because we spend most of our time in confined spaces: home, work, means of transport [4]. It has been shown that the comfort and well-being of employees in their workplaces directly affect their performance and productivity [5]. There are different types of indoor air pollutants, namely inorganic gases, volatile organic compounds (VOCs), particulates, airborne microorganisms and radon [1].

Despite the numeric revolution in the last years, printing still considered as a necessary tool in different sectors. Though, studies indicate that during printing or gluing processes multiple pollutants (VOCs, fine and ultrafine particles) are emitted in the indoor environment [6; 7]. Therefore, an increasing number of printing press facility employees complain about health problems, which are due to the exposure to machines.

Studies in this area are focused on VOC, however, analysis of emissions in these environments revealed the presence of fine particles (0.1...10 μm) and ultrafine (5...350 nm) particles. In fact, fine and ultrafine particles administered to the lung cause a greater inflammatory response. It appears also that ultrafine particles, after deposition in the lung, largely escape alveolar macrophage surveillance and gain access to the pulmonary interstitium [8]. It is therefore important to evaluate particulate emissions from different machines and their impact on the indoor environment.

The main objective of this work is to study the influence of printing and gluing machines on the indoor environment. Measurements of PM10, PM2.5 concentrations were carried out for several working shifts. Various cases have been studied in function with the number of operating machines. Measurements are also carried out in confined environments.

Materials and methods

The present study was carried out in a printing service located in La Rochelle city. The facility devised into different sections containing printers, cutting paper machines, gluing machines and storage rooms. The sampling campaign was conducted in three sections of the facility: two sections contain printing, gluing machines and in the reception desk (fig. 1). Section 1 (S1) contains a chamber which contains computers to program and activate printers. This room also contains three printers IM1, IM2, and IM3 arranged as schematized in figure 1. References of the three printers are shown in Table 1. Section 2 (S2) contains a gluing machine IM4. Positions of the ventilation openings and air conditioner are illustrated in Figure 1. The speed values at the inlet of the ventilation openings are of the order of 1.5 m/s. Velocities were measured using a hot wire anemometer type VELOCICALC PLUS 9545.

Particle concentration sampling was carried out using the Grimm model particle optical counter OPC with a sampling time of 1 min. Measurements were carried out according in three cases.

1. Measurement in S1 during a working shift when one printer is operating. The OPC has been placed in position P (fig. 1).
2. Measurement in S1 during one working shift when three printers are operating. The OPC has been placed in position P (fig. 1). Meanwhile, particle concentration in the reception desk was evaluated.
3. Confinement measurement, where a machine is covered with a plastic tarpaulin. Using this technique, emissions of two machines (IM3 and IM4) were evaluated.

During the measurements, doors between the different sections of the facility were kept open.

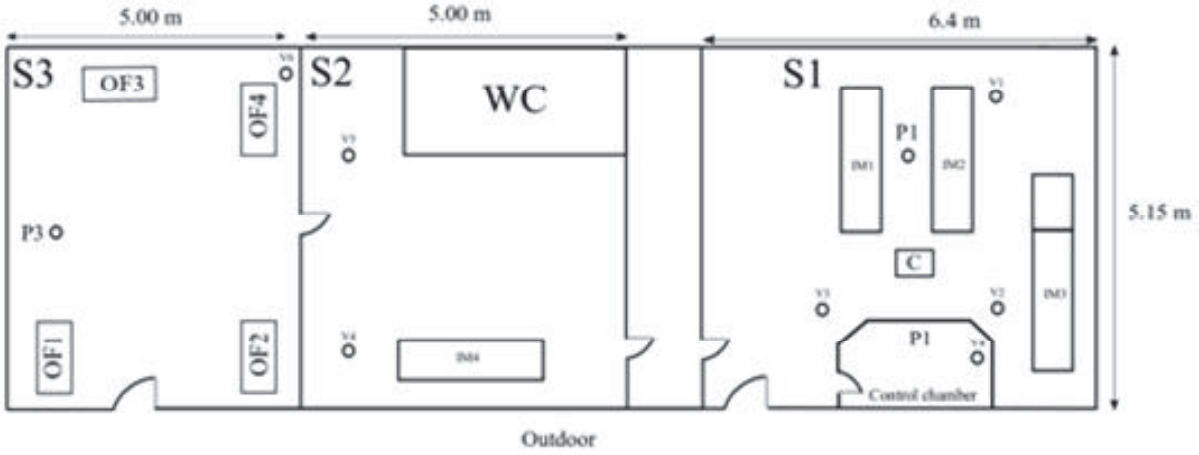

Fig. 1. Schematization of different sections of the press:
S1 − Section 1, S2 − Section 2, IM1, IM2,IM3 − Printers, IM4 − Gluing machine,
C − Air conditioning, V − Air opening, OF − Office, P − Sampling position

Table 1

References of the three printers

Machine name	References
IM1	PRO 8100s
IM2	PRO C7100s
IM3	BLOCKMATIC 350

Results

Table 2 shows a comparison between the PM10 and PM2.5 levels for the two cases 1 and 2 in section S1 and inside the control chamber. The table shows firstly similar values in S1 and in the control chamber. This is certainly, because the chamber is next to S1 and its door has been opening several times during the measurement period. Furthermore, the control chamber has a ventilation opening operating in a suction mode. Table 2 also shows a high average and maximum concentration values during case 2 measurement compared with case 1. The ratio between the maximum concentrations in the two cases reaches 4.3 for PM10 and 2.5 for PM2.5. Results show that limits set by the WHO were exceeded in case1 with ratios 3 for PM10 and 2 for PM2.5.

Table 3 shows the average of PM10 and PM2.5 concentrations in section S3 during case 2. To be noted that PM10 and PM2.5 concentrations reach values similar to those reached in section S1. This result reveals that particles emitted in S1 can reach the reception despite the fact the two sections are separated with S2. This affirms that the ventilation system used in the facility is not efficient to evacuate pollutant air to outdoor.

Figure 2 shows the evolution of PM10 and PM2.5 concentrations in the confined volume of IM3. The figure contains four pics which correspond to different operating phases of the printer. It can be noticed that in the absence of ventilation, concentration can reach high levels. However, in this case concentrations remain below the limits set by the WHO.

Figure 3 shows the temporal evolution of PM10 and PM2.5 concentrations under the tarpaulin near the gluing machine IM4. A high increase in concentration can be noticed after switching on the machine. Concentration reaches very high values 10 000 $\mu g/m^3$.

Containment technique highlights the real risk employees are exposed to when standing near the machine or in an extremely unfavorable case, for example during a turn off of the ventilation system.

Table 2

Comparison of average and daily maximum values of the different measures in S1

		S1		Chamber	
		PM10 ($\mu g/m^3$)	PM2.5($\mu g/m^3$)	PM10 ($\mu g/m^3$)	PM2.5($\mu g/m^3$)
Average	Case 1	25.00	15.70	24.10	15.10
	Case 2	**67.10**	24.95	**64.18**	24.66
Maximum	Case 1	36.00	19.40	35.74	19.30
	Case 2	**155.50**	47.60	**155.50**	**47.60**
WHO		50	25		

Table 3

Daily average and maximum values of PM10 and PM2.5 in the reception area

	PM10 ($\mu g/m^3$)	PM2.5 ($\mu g/m^3$)
Moyenne	**62.75**	20.75
Max	**121.8**	**35.5**

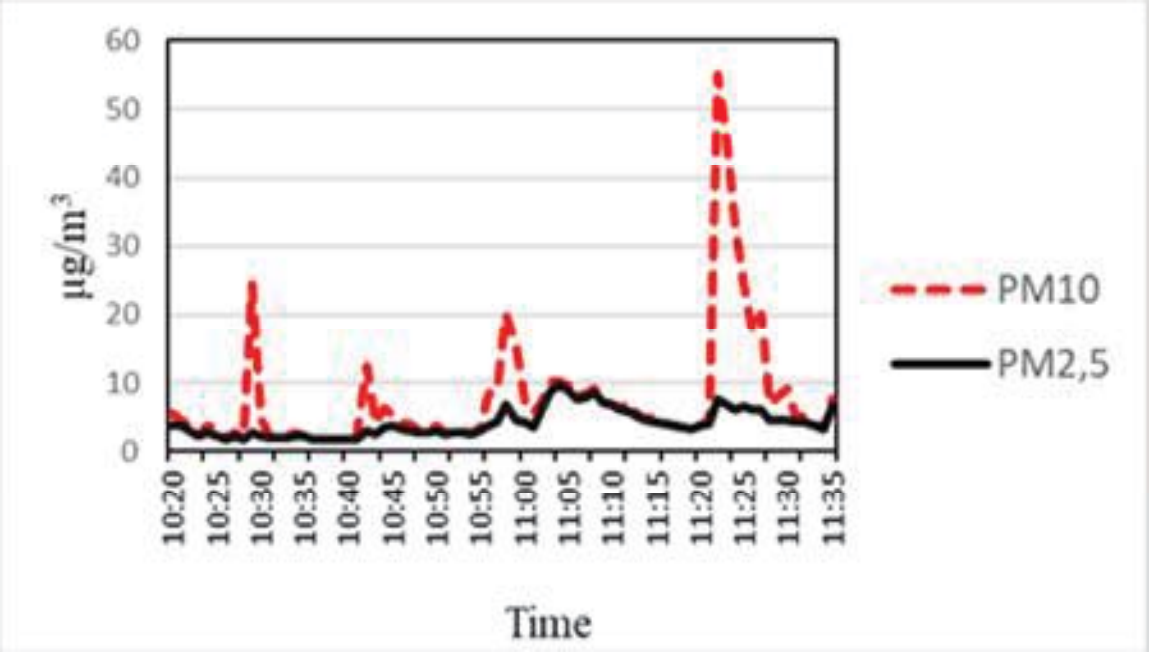

Fig. 2 : Temporal variation of PM10 and PM2.5 in the confined environment of IM3

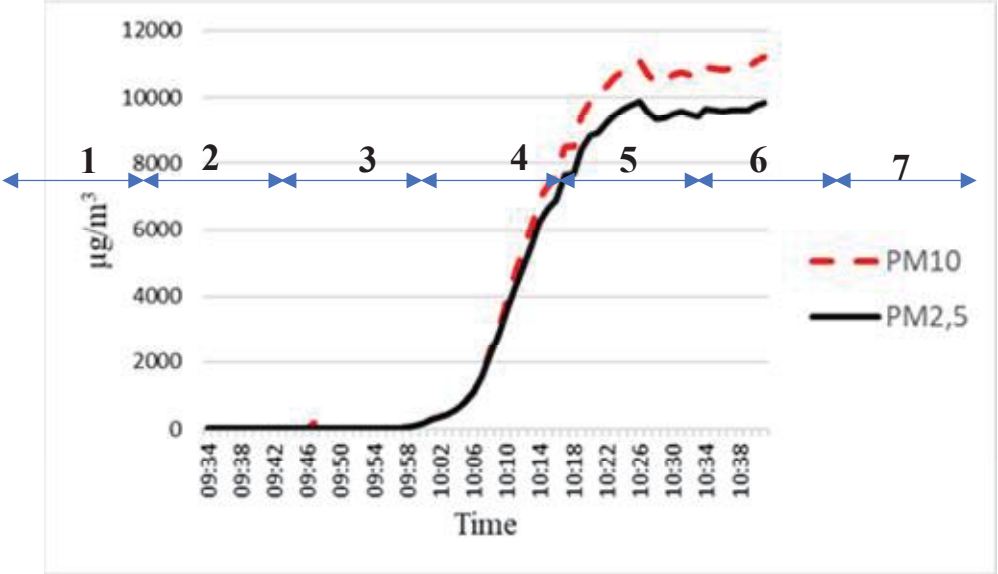

Fig. 3 . Temporal variation of PM10 and PM2.5 in the confined environment of IM4

Conclusion. Research conducted in this paper is an experimental contribution to evaluating particle emission levels in a printing facility during the gluing and printing processes. Measurements of PM10 and PM2.5 concentrations were carried out during working shifts in printing service. The findings obtained in this study significantly enhance our understanding of the levels and emission sources, which affect indoor concentrations.

Measurements have shown that, when all machines are running simultaneously, the maximum particle concentrations exceed the limits set by WHO. This result affirms the importance of ventilation system and the necessity of dispersing machines in a large. Concentration measurement in a confined environment allows evaluating the real risk that employees are exposed to.

The further study of the emission sources in a wide range of occupational environments as well as the measurements of the exposure levels at the employees' could be significant for knowledge and could help the development of the strategies for a healthier working environment.

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