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ORIGINAL RESEARCH PAPER

STUDY REGARDING THE MEASURING OF PARTICULATE MATTER $PM_{2.5}$ AND PM_{10} IN INDUSTRIAL WORKING ENVIRONMENTS

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Abstract: The air pollution is currently the biggest health risk and monitoring the air we breathe is more important than ever. Pollution with particulate matter $PM_{2.5}$ and PM_{10} can cause serious environmental problems (change in cloud formation, contribution to global warming, the change in the radiation balance of the Earth and reduced visibility) and affects human health (cardiovascular disease, pregnant women, the elderly, diabetic and those with lung disease). Occupational exposure to particulate matter is associated with respiratory health in the work environments. This paper aims to determine the pollution with $PM_{2.5}$ and PM_{10} in an industrial working environment.

Keywords: *air pollution, particulate matter, working environment*

INTRODUCTION

According to a World Health Organization report from 2015, air pollution is responsible for about 8 million deaths annually (there are approximately 4.3 million deaths due to domestic air pollution and 3.7 million deaths are due to outdoor air pollution) [1, 2].
Air pollution, if we refer to working conditions or in general, with evaluation of air composition or noise levels, can cause pulmonary disease, followed by heart disease and stroke, chronic and acute respiratory conditions [3 – 18].
The atmospheric pollutant linked most closely to excess disease and death is represented by the particulate matter $PM_{2.5}$ and PM_{10} [9, 10]. Particulate matter is a mixture of aerosol particles (solids and liquids) that comprise a wide range of chemical sizes and compositions [19 – 22].
In recent years, a special attention was given to the worldwide for the study to level of pollution with particulate matter $PM_{2.5}$ and PM_{10}. In the international scientific media, however, there is an increasing interest from year to year for the pollution with this type of particulate matter and for the influence that it induces on the health status of the population, being imposed lower and lower limits, from one year to another [19 – 25].
The Romanian legislation establishes maximum permissible limits for particulate matter through by Government Decision no. 584/2018 for the amendment Government Decision no. 1218/2006 regarding the minimum requirements for the safety and health at work for the protection of workers from risks related to chemical agents [26, 27].
A report made by the European Environment Agency shows that particulate matter PM_{10} are generated by agriculture (8.006 %), commercial, institutional and households (50.473 %), energy production and distribution (6.968 %), energy use in industry (7.21 %), industrial processes (28.606 %), non-road transport (1.731 %), road transport (10.799 %), solvent and product use (0.842 %), waste (0.798 %) and other sources (0.159 %) while $PM_{2.5}$ are generated by the agriculture (2.979 %), commercial, institutional and households (35.024 %), energy production and distribution (7.21 %), energy use in industry (8.381 %), industrial processes (9.08%), non-road transport (2.941 %), road transport (16.129 %), solvent and product use (1.430 %), waste (1.157 %) and other sources (0.159 %) [19].
Another report made by the World Health Organizations concluded that quantity of particulate matter ($PM_{2.5}$ and PM_{10}) identified in indoor environments are usually higher than the outdoor particulate matters levels [27].
Eštoková *et al.* [27] performed a monitoring for the concentrations of particulate matter in the indoor environment in three rooms of an apartment in the city of Kosice, Slovakia for a period of 28 days. As a result of this study, no exceedances of the concentration of particulate matter were identified in any of the rooms where the monitoring was carried out.
Another study conducted in 44 naturally ventilated schools in Belgrade, Serbia, on several parameters including PM_{10} showed that most children (76.2 %) are exposed to high concentrations of particulate matter PM_{10} in indoor spaces [28].
Another research was carried out in thirteen Portuguese optical shops providing contact lens services. It was identified that in eight of the thirteen shops the legal limits for particulate matter were exceeded. The results showed that in the customer waiting area the particulate matter PM_{10} had higher values compared to the optometry office. For

$PM_{2.5}$ although with higher values, no statistically significant differences were found between the samples [29].
Studies have also been conducted that identify the correlation between the amount of particulate matter in the indoor environments and the development of bacteria and microorganisms. Klánová and Hollerová [30] conducted a study in the rooms chosen due to the legal requirements of the quality of the interior environment. No correlation was identified between particulate matter count and the mould count in the indoor air.
From the reports presented above it can be seen that the industry is a major source of air pollution with particulate matter $PM_{2.5}$ and PM_{10}. It is also observed that the monitoring was carried out predominantly in civil environments and less in industrial areas. In this context, the present paper aims to determine the pollution with particulate matter $PM_{2.5}$ and PM_{10} in an industrial working environment.

RESEARCH METHODS

The study was performed based on the methodology presented in the Figure 1.

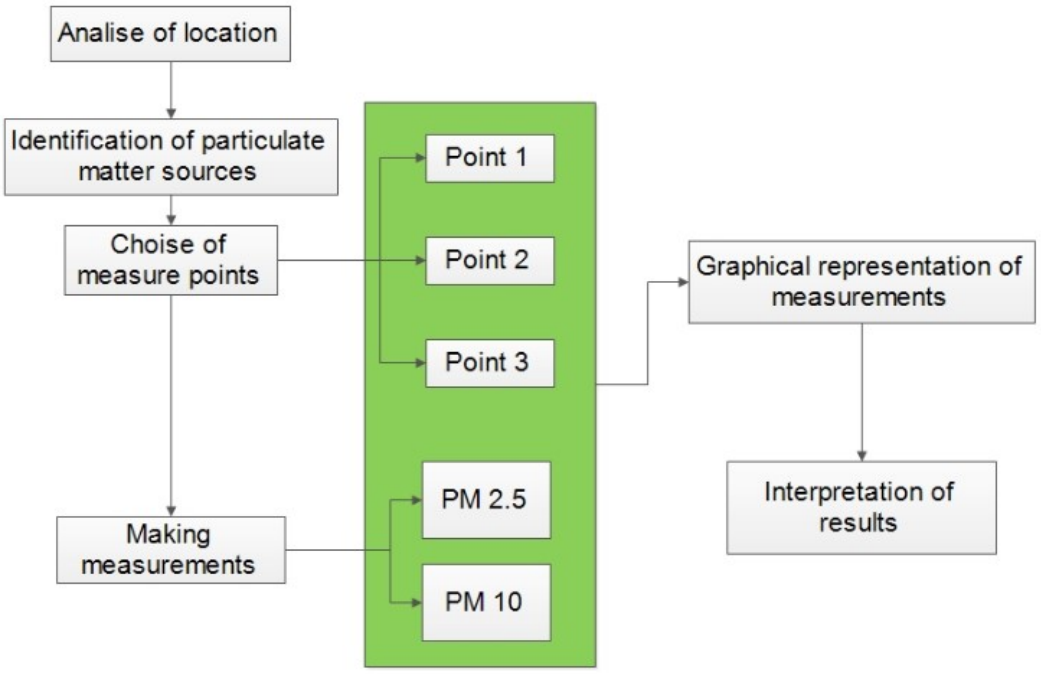

Figure 1. *Working methodology*

In order to determine the pollution with particulate matter $PM_{2.5}$ and PM_{10} in industrial working environments, we monitor some activities at a company whose activity objective is the repair of motors, transformers and electrical equipment from Bacau, Romania. The particulate matters generated by the cutting machine with water jet and abrasive powders MAXIEM 0707 were measured. Abrasive cutting with water jet at high pressure using a mixture of water and sand offers unlimited possibilities in terms of materials (metal, composite, glass, stone, tile, rubber etc.) and shapes, without the

material being mechanically or thermally charged. The material with which the cutting operation is performed is the natural garnet, material that has a granulation of 0.25 - 0.60 mm.
The measurements were made with the equipment for monitoring of particle matter CEL-712 Microdust Pro (Casella product). This equipment is portable and performs real-time measurements.
To determine the level of pollution with particulate matter $PM_{2.5}$ and PM_{10} the metal was used for the operation of water jet cutting. Two mechanical operations were performed: tearing material and cutting material. The measurements were made at the following points (Figure 2).

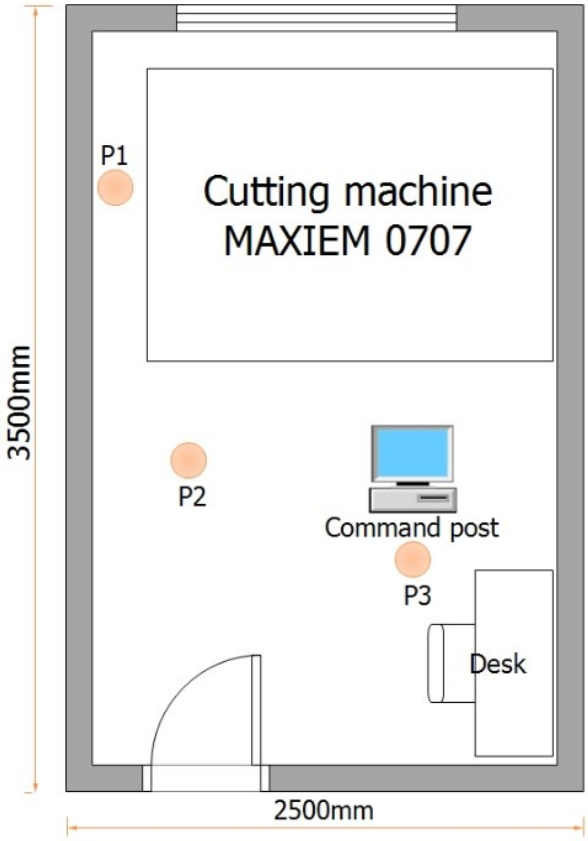

Figure 2. *The cutting machine with water jet and abrasive powders MAXIEM 0707: P1 - near the cutting machine with water jet and abrasive powders; P2 - at a distance of 50 cm from the cutting machine with water jet and abrasive powders; P3 - at the command post*

RESULTS AND DISCUSSIONS

The permissible limit value for particulate matter ($PM_{2.5}$ and PM_{10}) generated by the cutting machine with water jet and abrasive powders MAXIEM 0707 is 0.1 $mg \cdot m^{-3}$, according to the Government Decision no. 584/2018.
The values registered for the quantity of particulate matter $PM_{2.5}$ and PM_{10} in the tearing material phase are represented graphically in Figures 3 and 4.

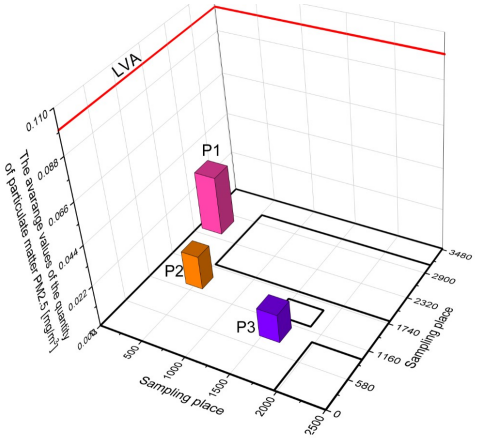

Figure 3. *Graphical representation for the quantity of particulate matter $PM_{2.5}$ in the tearing material phase*

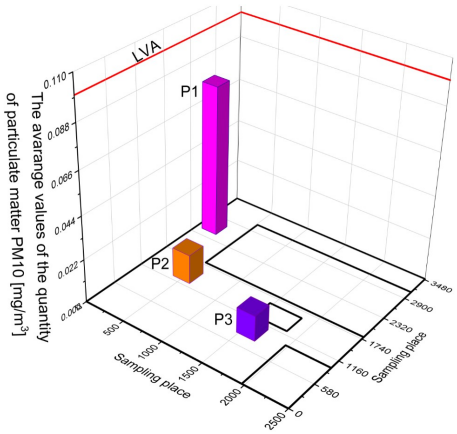

Figure 4. *Graphical representation for the quantity of particulate matter PM_{10} in the tearing material phase*

Following the measurements, it can be observed that the maximum permissible values for the particulate matter $PM_{2.5}$ and PM_{10} are not exceeded during the metal tearing phase, in any of the measuring places (near the cutting machine, at a distance of 50 cm from the cutting machine and at command post).

The values of measurements for the quantity of particulate matter $PM_{2.5}$ and PM_{10} performed in cutting material phase are plotted Figures 5 and 6.

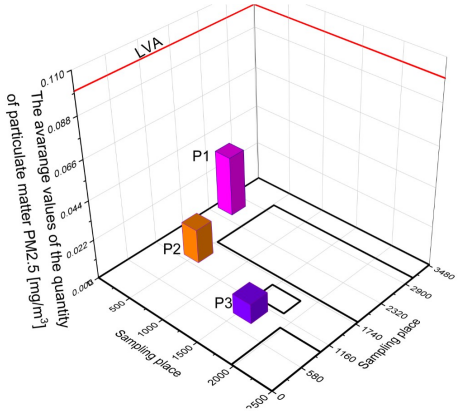

Figure 5. *Graphical representation for the quantity of particulate matter $PM_{2.5}$ in the cutting material phase*

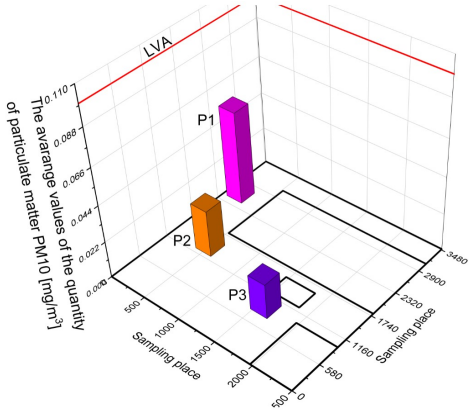

Figure 6. *Graphical representation for the quantity of particulate matter PM_{10} in the cutting material phase*

Regarding the measurements made in the material cutting phase, it can also be observed that the maximum permissible values for particulate matter $PM_{2.5}$ and PM_{10} were not exceeded in any of the measuring places (near the cutting machine, at a distance of 50 cm from the cutting machine and at command post).

Also, following the experiments carried out at analyzed company, on the cutting machine with water jet and abrasive powders MAXIEM 0707, it was found that the data are in accordance with the research carried out by the Eštoková *et al.* [27] and Klánová

and Hollerová [30]. In both cases it was found that there is no exceedance of maximum permissible values for particulate matter $PM_{2.5}$ and PM_{10}.

CONCLUSIONS

Air pollution has been of major concern throughout the world due to the health effects on human, animal and materials.
An active source of air pollution in an industrial working environment is represented by the particulate matter $PM_{2.5}$ and PM_{10}.
In the present study, have been measured particulate matters generated by the cutting machine with water jet and abrasive powders MAXIEM 0707, in two phases of work, tearing material phase and cutting material phase. Were used three measuring points, near the cutting machine, at 50 cm from the cutting machine and at command working point.
After performing the experiments, it can be observed that the maximum permissible values for the particulate matter $PM_{2.5}$ and PM_{10} are not exceeded in the two phases of work. It is thus found that the working environment the cutting machine with water jet and abrasive powders MAXIEM 0707 is not harmful to the health of the employees.
Further investigations regarding cutting for other types of materials (composite, glass, stone, tile, rubber) would be important to provide information to public health stakeholders from indoor environments.

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