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Studies on the exposure of workers to fine particles from diesel engine exhaust emissions generated in urban transport

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Abstract. The paper presents the results of the studies on the exposure of workers who may face exhaust emissions of diesel engines from urban transport. Many workers such as drivers, toll booth workers, security guards, public domain workers, police officers may be exposed daily to the chemical pollutants from urban transport. It is estimated that 52% of annual occupational deaths in the European Union can be attributed to work-related cancers. The study responds to the actions to prevent the exposure of workers to carcinogens that the European Commission has included in the *Europe's Beating Cancer Plan* adopted in early 2021.

1 Introduction

Cancer is the leading cause of occupational death in the European Union (EU). Every year in Europe, there are around 100,000 deaths from occupational cancer at work [1]. Diesel engine emissions are among the carcinogens present at work. In 2012, the International Agency for Research on Cancer (IARC) classified diesel engine emissions as carcinogenic to humans (Group 1). Exposure to diesel emissions is associated with an increased risk of lung cancer. It is estimated that more than 3,6 million workers in Europe are exposed to diesel emissions [2]. In the United States, more than one million workers are exposed to diesel emissions at work, and in Canada about 897,000 workers are exposed to diesel engine emissions each year [3].

In Romania, approximately 50,000 people die each year from cancer [4], but the number of deaths caused by exposure to diesel emissions is unknown.

Diesel engine emissions are pervasive, a public health issue, but occupational exposures pose a greater risk because they are generally much higher. Chronic exposure to fine particles generated during the combustion of fuels present in the air can lead to lung cancer [5, 6]. In urban environments, diesel engine exhaust (DEE) emissions are a major source of

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particulate matter pollution. Actions to combat cancer in the workplace are key components of the Europe's Beating Cancer Plan [7], which sets out a new EU approach to cancer prevention, treatment and sustainable care. The EU's commitment to combating cancer in the workplace is also in line with the strategy on carcinogens for 2020-2024, in order to rapidly implement the new thresholds for carcinogens, thus improving working conditions for around 40 million workers. The direct costs of occupational exposure to carcinogens across Europe are estimated at € 2.4 billion per year [8].

Directive (EU) 2019/130 on the protection of workers from the risks related to exposure to carcinogens or mutagens at work [9] introduces an occupational exposure limit value (OEL) for the exhaust emissions of diesel engines of 0.05 mg/m^3, measured as elemental carbon. In Romania, the mandatory occupational exposure limit value for 8 hours is provided in Annex 1 of the Government Decision (GD) of Romania no. 1218/2006 amended by GD no. 53/2021 which adopted the EU limit and which will be mandatory starting with 2023 [10].

It is important to highlight that setting an occupational exposure limit value in relation to carcinogens or mutagens does not eliminate the risks to the workers' health, but contributes to a significant reduction in risks arising from the exposure [11].

Therefore, until now, there has been no studies published on monitoring of workers in Romania exposed to diesel engine emissions, mainly due to the lack of data and adequate equipment required by the dedicated analytical methods. The PN 19 44 05 02 Project, carried out in the period 2019-2022, developed a method for the determination of elemental carbon (EC) based on other existing methods at international level used to measure such exposures (for example, the NIOSH 5040 method [12]). At this stage, the project research has shown that although there have been no OEL exceedances, in the monitored cases, there is still a long-term exposure, and measures are needed as well as protection even for the lowest levels of exposure, where some of the components are genotoxic carcinogens.

2 Methodology

The study established three static points for collecting diesel emissions caused by urban transport in Bucharest. The samplings were performed during 2021-2022, at different time intervals of the day, 8-10 am and 2-4 pm when the traffic is very busy/intense.

a

b

Fig. 1. Exposure to diesel emission in crowded areas: a) policeman; b) street shops.

The sampling points were established at a distance of approximately 3 m from the road of road vehicles, in crowded areas. There are no additional sources of pollution with particles generated by other combustion in the immediate proximity. At least five categories of workers that could be considered for this type of exposure have been identified, such as: drivers, toll booth workers, security guards, public domain workers, police officers (fig 1 a - b).

After transporting the samples to the laboratory, a representative portion of the filter (sample) was cut using a 1x1.5 cm^2 precision punch. EC analysis was performed with an OC/EC thermo-optical analyzer (fig. 2).

Fig. 2. OC/EC analyzer with FID detector for determination Organic Carbon (OC), Elemental Carbon (EC) and Total Carbon (TC) by thermal/optical analysis.

One field control filter (field blank), identical to the sampling one, was prepared, transported to the sampling site and analyzed for EC in the same way as sample filters. To determine the EC concentrations of diesel emissions the results from the analyzer, expressed in μgC/cm^2, were converted to mg/m^3, using the flow rate and sampling time. For the volume obtained at the pressure and temperature during sampling the correction was made at 20°C and 101.3 kPa.

3 Results

The measured data were expressed as 8h TWA concentration of EC. The results are comparable for the three points at which measurements were made.

Over 60% of the results are below the detection limit of the method (0.0010 mg/m^3), and less than 40% of the results are between 0.0011 and 0.0157 mg/m^3 (tab. 1, fig. 3).

Table 1. EC monitoring results for three static points (>0.0010 mg/m^3)

EC CONCENTRATIONS OF DIESEL EMISSIONS (mg/m^3)			
year	Sampling point 1	Sampling point 2	Sampling point 3
2021	0.0063	0.0004	0.0011
	0.0011	0.0011	0.0011
	0.0012	0.0001	0.0052
	0.0042	0.0001	0.0044
	0.0102	0.0047	0.0058
	0.0101	0.0031	0.0011
	0.0021	0.0021	0.0014
	0.0072	0.0051	0.0048
	0.0081	0.0011	0.0052
	0.0088	0.0032	0.0055
	0.0092	0.0052	0.0069
	0.0098	0.0052	0.0043
	0.0104	0.0068	0.0067
	0.0102	0.0052	0.0071
	0.0106	0.0042	0.0074
2022	0.0092	0.0033	0.0088
	0.0107	0.0033	0.0042
	0.0103	0.0064	0.0086
	0.0119	0.0043	0.0091
	0.0125	0.0064	0.0093
	0.0141	0.0046	0.0107
	0.0157	0.0056	0.0101

There is a slight growth tendency of concentrations in recent times when traffic has been much more intense, given that 80% of monitoring was carried out during the pandemic when traffic was greatly reduced due to work from home.

An increase of the concentration within the traffic was observed, especially when comparing recent values (the first half of the year 2022) with values during the pandemics (2021).

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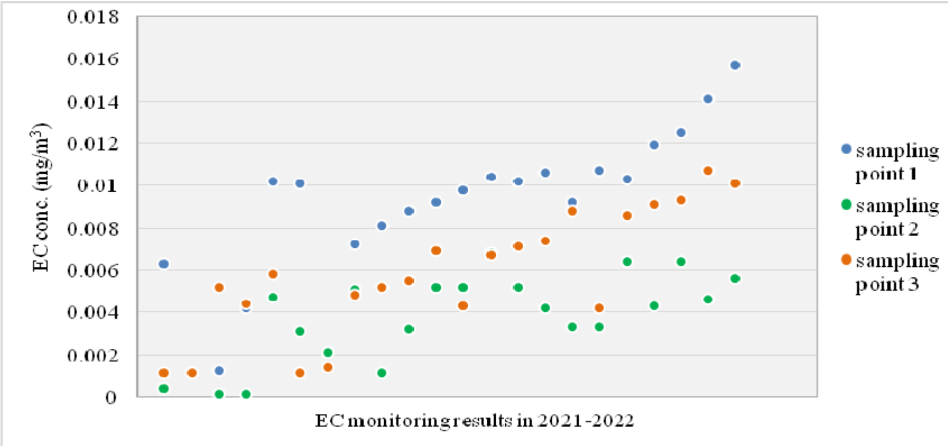

Fig. 3. About 40% of the EC monitoring results are between 0.0011 and 0.0157 mg/m^3.

4 Conclusions

Even no exceedances of the binding OEL were registered during the monitoring campaigns in 2020 and 2021, there is still an exposure in certain periods, in particular when the traffic is intense. Particulate matter emissions from diesel engines are considerably higher (six to ten times) than from gasoline engines. Air pollution caused by diesel engine emissions, especially particulate matter, is one of the biggest problems of current transportation. DEE are the most prevalent anthropogenic pollutants and becoming increasingly widespread in densely populated urban regions [13-15].

Risk management measures should be implemented in order to reduce the workers' exposure to diesel engine emissions to as low a level is technically and practically possible, in line with the provisions of the Directive 2004/37/EC [11]. Monitoring exposure to diesel emissions can improve risk assessment, which requires appropriate preventive measures [16].

Monitoring campaigns should be continued, including also personal sampling, as part of these measures. The measurements should be representative of the nature and duration of the tasks and the number of workers potentially exposed to diesel engine emissions, and include contextual information.

Further research and studies will address the issue on the limited data and information on the diesel engine exhaust emissions, and will contribute to provide a more accurate picture on the workers' exposure.

The campaigns to raise awareness and inform workers and employers about the carcinogenic effects and risks of diesel engine emissions should also be continued.

Information, training and instruction should include the exposure risks, the measures implemented and how to use and maintain them correctly, and be provided in a way easy to understand. Supervision should be performed to ensure safety procedures are followed, especially where organizational measures are used to minimize the emissions [17].

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