

PM10 AND PM2.5 EMISSION AND ANALYSIS FROM RESIDENTAL COMPLEX CONSTRUCION SITE IN SREMSKA KAMENICA, SERBIA

Aleksandra Čavić¹, Boris Obrovski¹, Sanja Dubljević², Vladimir Rajs², Miljan Šunjević²

¹*Faculty of Economics and Engineering Management, University Business
Academy in Novi Sad, Cvečarska 2, Novi Sad, Serbia*

²*Faculty of Technical Sciences, University of Novi Sad, Trg Dositeja Obradovića 6, Novi Sad
e-mail: msunjevic@uns.ac.rs*

Abstract

Construction sites are recognized as significant non-industrial sources of particulate matter (PM10 and PM2.5), contributing to the degradation of urban air quality and posing health risks for workers and nearby residents. The research quantified emissions from a residential complex construction site in Sremska Kamenica, Serbia, by applying the EMEP/EEA Air Pollutant Emission Inventory Guidebook (Tier 1 methodology). The active construction area was defined as 3,500 m², operating under a continuous 365-day work schedule. Annual emissions were estimated at 207 kg for PM10 and 59.5 kg for PM2.5, corresponding to daily emissions of 568 g and 163 g, respectively. Dispersion modeling using a box approach yielded hourly average concentrations of 112 µg/m³ for PM10 and 11.2 µg/m³ for PM2.5. Risk assessment, based on a 10-hour work shift and an inhalation rate of 1.25 m³/h, indicated daily doses of 1,400 µg of PM10 and 140 µg of PM2.5 per worker. When compared with WHO Air Quality Guidelines, PM2.5 remained within acceptable levels, while PM10 concentrations exceeded recommended thresholds by more than 2.5 times, yielding a Hazard Quotient of 2.49. These findings identify PM10 as the dominant polluting substance of concern, highlighting the necessity of implementing dust suppression measures such as watering, soil stabilization, vehicle speed control, and protective equipment.

Introduction

Suspended particulate matter (PM10 and PM2.5) is recognized as one of the most critical polluting substances in urban air, exerting a direct influence on public health and environmental quality [1]. Prolonged exposure to elevated concentrations of airborne particles has been linked to increased incidence of respiratory and cardiovascular diseases, as well as reduced overall life expectancy [2], [3]. According to the World Health Organization (WHO), there is no safe threshold for exposure to particulate matter, which underscores the importance of accurate monitoring and reliable emission assessment, particularly in urban areas undergoing rapid development.

Construction activities are among the most significant non-industrial sources of particulate matter emissions. Processes such as excavation, demolition, material handling, on-site transport, and equipment movement disturb soil and release dust into the atmosphere [4], [5]. Although temporary in nature, these emissions can lead to substantial short-term degradation of local air quality. Their impact is especially pronounced in densely populated areas where ventilation is limited and background pollution levels are already elevated.

Experimental

The observed construction site is situated in Sremska Kamenica (45°13'29"N, 19°51'23"E), a suburban settlement of Novi Sad, Serbia, positioned along the right bank of the Danube River (Figure 1.). The Parcel is 16,814 m² while estimated construction area is 10,000 m², as project is designed in 3 phases the observer area in the research covers a 3,500 m² complex, embedded

within a mixed-use urban environment. The immediate surroundings are characterized by low-rise residential housing, local commercial facilities, and public service infrastructure, with arterial roads of moderate traffic intensity contributing additional background air pollution. In the vicinity of the construction site is Institute of Cardiovascular Diseases, Sremska Kamenica, which is regional healthcare center. Vegetation is present in the form of fragmented green corridors and riverside belts; however, the effective Leaf Area Index is relatively low, providing limited mitigation capacity against airborne particulate matter. Due to the site's position within a partially enclosed urban canopy, natural ventilation is constrained, particularly under meteorological conditions of low wind speed and atmospheric stability. This creates conditions in which construction-generated dust can accumulate locally, significantly elevating ambient concentrations of PM₁₀ and PM_{2.5} and thus intensifying exposure risks for workers and nearby residents.



Figure 1. Residential complex construction site location in Sremska Kamenica, Serbia

The quantification of particulate matter (PM₁₀ and PM_{2.5}) emissions from the construction site was performed by applying the EMEP/EEA Air Pollutant Emission Inventory Guidebook (Tier 1 methodology). This methodology provides default emission factors for construction activities, expressed per unit area, and represents a transparent baseline for dust emission estimates in the absence of local measurements.

The active construction zone was defined as 3,500 m² (0.35 ha). Using Tier 1 factors, this produced 207 kg/year of PM₁₀ and 59.5 kg/year of PM_{2.5}. Unlike conventional approaches that distribute annual emissions over a standard working year of 250 days, in this scenario we used the real data from investors, where they have been working continuous operation over 365

days without interruption. Under these conditions, the calculated daily emissions were 568 g/day for PM₁₀ and 163 g/day for PM_{2.5}.

To estimate near-ground concentrations, a box-model dispersion approach was applied. The control volume was defined as the active surface (3,500 m²) with a mixing height of 10 m, yielding a dispersion volume of 35,000 m³. Daily emissions were divided by this volume to obtain average concentrations of 16.2 µg/m³ for PM₁₀ and 4.7 µg/m³ for PM_{2.5}. Assuming uniform distribution of emissions across the working day, the hourly concentrations were determined as 112 µg/m³ for PM₁₀ and 11.2 µg/m³ for PM_{2.5}.

The risk assessment was performed using the modeled concentrations. Worker exposure was evaluated under the assumption of 10-hour workdays, with an inhalation rate of 1.25 m³/h, yielding daily inhaled doses of approximately 1,400 µg/day for PM₁₀ and 140 µg/day for PM_{2.5}. A hazard quotient (HQ) approach was applied to assess non-carcinogenic risk, defined as the ratio of observed concentration to the reference value.

Results and discussion

Using the EMEP/EEA Tier 1 methodology, annual emissions for the 3,500 m² active construction zone were calculated as 207 kg/year (568 g/day) for PM₁₀ and 59.5 kg/year (163 g/day) for PM_{2.5}. By applying a box-model dispersion, distributed across the workday, hourly averages were 112 µg/m³ for PM₁₀ and 11.2 µg/m³ for PM_{2.5}. Modeled PM emission values are presented in Table 1. Assuming a 10-hour work shift with an inhalation rate of 1.25 m³/h, the estimated inhaled doses per worker were:

- 1,400 µg/day for PM₁₀
- 140 µg/day for PM_{2.5}

Table 2. PM emission modeled values

Pollutant	Modeled Concentration (µg/m ³)	WHO limits (µg/m ³)	Hazard Quotient
PM ₁₀	112	45	2.49
PM _{2.5}	11.2	15	0.75

The HQ for PM₁₀ was 2.49, indicating that concentrations substantially exceed WHO health-based thresholds, and therefore represent an unacceptable level of risk under continuous exposure. In contrast, the HQ for PM_{2.5} was 0.75, remaining below the guideline value and within acceptable limits, though chronic exposure could still contribute to cumulative health effects.

The results demonstrate that PM₁₀ concentrations exceed WHO air quality guidelines by approximately 2.5 times, representing an unacceptable risk level under continuous exposure. PM_{2.5} concentrations remain below the threshold but contribute to cumulative inhaled dose, particularly under year-round exposure conditions.

When compared to OSHA occupational exposure limits (5,000 µg/m³ for respirable dust), both pollutants are well below regulatory thresholds. However, OSHA standards are not designed to protect against long-term health impacts, while WHO guidelines are explicitly health-based. For this reason, PM₁₀ exposure remains the primary concern in terms of worker health and long-term morbidity. This indicates that PM₁₀ emissions require immediate attention, and that effective dust suppression measures — such as watering, soil stabilization, vehicle speed limits, and protective equipment — should be implemented to reduce risks.

Conclusion

The research applied the EMEP/EEA Tier 1 methodology to quantify emissions of suspended particulate matter from a construction site in Sremska Kamenica, with a focus on a 3,500 m² active area operating continuously for 365 days per year. The results indicate that annual emissions amount to approximately 207 kg of PM₁₀ and 59.5 kg of PM_{2.5}, corresponding to daily emissions of 568 g and 163 g, respectively.

Dispersion modeling using a simplified box approach yielded hourly concentrations of 112 µg/m³ for PM₁₀ and 11.2 µg/m³ for PM_{2.5}. When compared with the WHO Air Quality Guidelines, PM_{2.5} levels remain within acceptable limits, while PM₁₀ concentrations exceed recommended thresholds by more than 2.5 times, resulting in a Hazard Quotient of 2.49. This categorizes PM₁₀ exposure as a high-risk condition under continuous operation, while PM_{2.5} remains in the low-to-medium risk range.

The findings highlight PM₁₀ as the dominant polluting substance of concern for occupational exposure on construction sites. Although absolute concentrations are far below OSHA occupational exposure limits, these values do not account for long-term health impacts. Continuous exposure, especially during 10-hour work shifts, increases daily inhaled doses and raises the likelihood of adverse respiratory outcomes.

In conclusion, while Tier 1 modeling provides a conservative upper-bound estimate, it clearly demonstrates the necessity of implementing PM suppression measures (e.g., watering, soil stabilization, speed control, protective equipment) to mitigate worker exposure.

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