**Monitoring Volatile Organic Compounds in Indoor and Outdoor Air Using Passive Sampling in Milan, Italy**

**Vllaznim Mula 1,2,5\*,**

Jane Bogdanov5, Jasmina Petreska Stanoeva5, Lulzim Zeneli1, Fabrizio Gelmini2, Armond Daci3, Avni Berisha4, Zoran Zdravkovski5, Giangiacomo Beretta2

*1 University “Fehmi Agani”, 50000 Gjakovë, Kosovo*

*2 Department of Environmental Science and Policy, Università degli Studi di Milano, Milan, Italy*

*3 Department of Pharmacy, Faculty of Medicine, University of Prishtina, 10000 Prishtina, Kosovo*

*4 Department of Chemistry, Faculty of Natural and Mathematics Science, University of Prishtina, 10000 Prishtina, Kosovo*

*5 Institute of Chemistry, Faculty of Natural Sciences and Mathematics, Ss. Cyril and Methodius University in Skopje, 1000 Skopje, N. Macedonia*

vllaznim.mula@uni-gjk.org

Volatile organic compounds (VOCs) are significant contributors to urban air pollution, affecting both human health and environmental quality [1]. This study aimed to monitor VOC levels in indoor and outdoor environments at five locations in Milan, Italy, over a two-month period during the summer of 2024, a time characterized by high emissions and intensified photochemical activity. Using Radiello® passive samplers and gas chromatography-mass spectrometry (GC-MS), the VOC concentrations were measured and the emission profiles of household cleaning and personal care products were analysed to assess their impact on indoor air quality. The results showed that the average total VOC concentration (TVOCs) outdoors was 220.8 ± 195.4 µg/m³, while indoor levels were slightly higher at 243.6 ± 134.3 µg/m³, resulting in an indoor-to-outdoor ratio of 1.32 ± 0.719. These concentrations surpass typical background levels in other European cities [2], underscoring the complex nature of VOC emissions in Milan. The most abundant VOC group in both environments were alkanes, although their relative distribution differed. Outdoors, the predominant groups were alkanes > aromatic hydrocarbons > alkenes > terpenes > esters > alcohols & ethers > halogenated compounds > organosiloxanes > aldehydes & ketones. Indoors, alkanes and terpenes were dominant, followed by esters, alcohols & ethers, aromatic hydrocarbons, and other compounds. To further assess the dynamics of VOCs, the (*m + p*)-xylene to ethylbenzene (X/E) ratio was employed as an indicator of photochemical aging [3, 4]. Notably, the recommended indoor TVOC threshold of 200 µg/m³, established by Mølhave to minimize discomfort and health risks, was exceeded in three out of four monitored apartments.

**Acknowledgments**

We express our sincere gratitude for the funding provided by the European Commission under the project titled “Nanoparticles in Environment and Medical Research” (NanoKos - 438247).

**References**

[1] McDonald BC, de Gouw JA, Gilman JB, et al. Volatile chemical products emerging as largest petrochemical source of urban organic emissions. *Science (1979)* 2018; 359: 760–764.

[2] De Coster G, Van Overmeiren P, Vandermeersch L, et al. Indoor and outdoor air quality assessment in daycare centres in Ghent (Belgium) in view of outdoor sleeping in an urban environment. *Atmos Environ* 2023; 303: 119711.

[3] Xue Y, Ho SSH, Huang Y, et al. Source apportionment of VOCs and their impacts on surface ozone in an industry city of Baoji, Northwestern China. *Sci Rep* 2017; 7: 9979.

[4] Mula V, Bogdanov J, Stanoeva JP, et al. Monitoring Volatile Organic Compounds in Air Using Passive Sampling: Regional Cross-Border Study between N. Macedonia and Kosovo. *Aerosol Air Qual Res* 2024; 24: 230170.