

PRESENCE OF POLLUTANTS IN THE AIR OF THE INDUSTRIAL AND URBAN AREAS OF THE MUNICIPALITY OF LUKAVAC

PROFESSIONAL PAPER

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ABSTRACT:

Economic, technological, and industrial development, along with rising energy demand in Tuzla Canton, particularly in the municipality of Lukavac has led to increased air pollution and environmental degradation, affecting water and soil quality. This paper analyzes data on air pollutants in the urban and industrial areas of Lukavac for 2018 and 2019. Data for the urban area were obtained from the Ministry of Environmental Protection of Tuzla Canton, while industrial data came from Global Ispat Coke Industry Lukavac. In 2018, sulfur dioxide levels in the urban area exceeded limit values, while PM_{2.5} and nitrogen oxides were particularly high during winter months due to natural and anthropogenic factors. Carbon monoxide remained within permitted levels. In 2019, sulfur dioxide and particulate matter occasionally exceeded limits, while nitrogen oxides, ozone, and carbon monoxide were below them. In the industrial zone, annual concentrations of carbon monoxide, sulfur dioxide, hydrogen sulfide, and particulate matter exceeded permitted values in both years, although sulfur dioxide and nitrogen oxides met regulatory limits. Air pollution poses serious health risks, increasing respiratory and cardiovascular diseases, especially among vulnerable groups such as the elderly, children, pregnant women, and industrial workers.

KEYWORDS: air pollution, pollutants, urban area, industrial area

INTRODUCTION

Rapid economic and industrial development in Tuzla Canton, particularly within the municipality of Lukavac, has significantly affected environmental quality. The accelerated expansion of industrial capacity, urbanization, and energy consumption has led to increasing emissions of harmful substances into the atmosphere. Lukavac represents one of the most industrialized municipalities in Bosnia and Herzegovina, hosting major industrial facilities such as the Global Ispat Coke Industry (GIKIL), Lukavac Cement Plant, and Soda Factory Lukavac. These facilities emit substantial quantities of pollutants in gaseous, liquid, and particulate forms, contributing to air, water, and soil degradation.

In addition to industrial sources, the rapid growth of the urban population, industrialization, and the intensification of traffic represent major challenges for maintaining air quality [1]. Transportation of any kind enables greater mobility but, in return, requires large

amounts of oxygen for fuel combustion and releases carbon dioxide and carbon monoxide into the atmosphere [2]. Air pollutants such as sulfur dioxide (SO₂), nitrogen oxides (NO_x), carbon monoxide (CO), ozone (O₃), and particulate matter with aerodynamic diameters below 10 μm and 2.5 μm are considered key indicators in air quality assessment, as they have harmful effects on human health and ecosystems [3]. Air pollution in this area is not an isolated issue but part of a broader regional environmental problem that extends across the Tuzla industrial basin. According to the European Environment Agency [4], industrial activity accounts for more than half of total emissions of major air pollutants in Europe, particularly sulfur dioxide (SO₂), nitrogen oxides (NO_x), and particulate matter (PM₁₀ and PM_{2.5}). In developing regions such as Bosnia and Herzegovina, these emissions are further amplified by outdated technology, inefficient combustion processes, and the use of high-sulfur fuels.

Air pollution poses one of the most serious threats to public health and environmental sustainability. The World Health Organization [5] [5] has established air quality guidelines specifying threshold concentrations for major pollutants to protect human health. However, in many industrial zones of the Western Balkans, including Lukavac, these limits are frequently exceeded. Long-term exposure to air pollutants, particularly fine particulate matter (PM_{2.5}) and sulfur compounds, has been associated with respiratory illnesses, cardiovascular diseases, and increased mortality rates [6].

The primary objective of this research is to analyze the presence and concentration of major air pollutants in both the urban and industrial zones of the municipality of Lukavac for the years 2018 and 2019, using data from authorized monitoring stations. The study also aims to evaluate compliance with national and international air quality standards and to discuss the implications of air pollution on environmental and human health.

MATERIALS AND METHODS

Study Area

The municipality of Lukavac is located in the northeastern part of Bosnia and Herzegovina, within Tuzla Canton. It covers an area of approximately 338 km² and has a population of around 45000 inhabitants. The climate is continental, with cold winters and warm summers, conditions that influence the dispersion and accumulation of pollutants. The area is characterized by dense industrial infrastructure, residential zones in close proximity to factories, and moderate traffic density.

Two distinct monitoring sites were considered:

1. Urban area– located in the central part of Lukavac, representing exposure in residential and commercial zones.
2. Industrial area – located near GIKIL facilities, representing direct influence from industrial emissions.

Data Sources

Data for the urban area were obtained from the *Ministry of Environmental Protection of Tuzla Canton*, which supervises continuous automatic monitoring stations. Measurements for the industrial area were provided by *Global Ispat Coke Industry Lukavac*, based on their mandatory emission monitoring under the environmental permit issued by the Federal Ministry of Environment and Tourism.

Pollutants Analyzed

The following pollutants were analyzed:

- **Sulfur dioxide (SO₂)** – a key product of coal and coke combustion.
- **Nitrogen oxides (NO_x)** – formed during high-temperature combustion.
- **Carbon monoxide (CO)** – product of incomplete combustion of fossil fuels.
- **Ozone (O₃)** – secondary pollutant formed through photochemical reactions.
- **Hydrogen sulfide (H₂S)** – emitted from coking and chemical processes.
- **Particulate matter (PM₁₀ and PM_{2.5})** – fine and coarse particles contributing to smog and health impacts.

The concentration of pollutants was expressed in µg/m³ for gases and suspended particles. The data were compared against **national limit values** established by the *Regulation on Air Quality Monitoring in the Federation of Bosnia and Herzegovina* [8] - [12] and WHO standards.

Methodology

The study employed a descriptive analytical method, processing monthly and annual average concentrations for 2018 and 2019. The analysis included:

- identification of pollutants exceeding limit values;
- seasonal variation analysis, with special focus on winter months;
- comparison between urban and industrial monitoring sites;
- assessment of potential health implications.

The data were statistically summarized using mean values and exceedance frequencies. No modeling was performed; instead, observational trends were emphasized to establish the current state of air quality and its temporal behavior.

RESULTS AND DISCUSSION

Air Quality in the Urban Area

The analysis for 2018 showed that concentrations of sulfur dioxide (SO₂) in the urban part of Lukavac exceeded the permitted limit of 125 µg/m³ for 24-hour averages, particularly during December and January (Table 1). This seasonal increase corresponds to higher coal consumption for domestic heating and temperature inversions that trap pollutants near the surface.

Particulate matter (PM_{2.5}) levels were consistently above 25 µg/m³, with peaks reaching over 60 µg/m³

during winter months, exceeding both WHO and EU limits. Nitrogen oxides (NO_x) also showed elevated concentrations, reflecting contributions from traffic and combustion processes. Carbon monoxide (CO) levels remained below 10 mg/m³, within acceptable limits.

In 2019, air quality patterns were similar, though slightly improved due to temporary reductions in industrial output. SO₂ and PM values still exceeded regulatory thresholds, while NO_x and CO

concentrations were below limits. Ozone (O₃) values remained low throughout the year, consistent with colder climatic conditions and limited photochemical activity.

These findings align with prior studies [7] indicating that urban air quality in Lukavac is primarily influenced by combined residential and industrial emissions, exacerbated by unfavorable meteorological conditions.

Table 1. Overview of average monthly values of monitored parameters in the urban part of the city during 2018.

Month	SO ₂ (µg/m ³)	NO ₂ (µg/m ³)	CO (mg/m ³)	O ₃ (µg/m ³)	PM2.5 (µg/m ³)
January	65.14	35.31	1.92	10.45	93.81
February	63.12	30.05	1.06	15.82	56.71
March	57.62	42.56	0.94	26.82	62.83
April	49.43	26.61	0.56	27.91	31.74
May	56.67	17.75	0.34	42.39	32.55
June	42.60	14.50	0.24	36.46	23.08
July	51.01	11.91	0.26	38.68	24.99
August	59.38	12.63	0.39	56.46	31.65
September	61.04	16.65	0.55	0.00	27.40
Oktober	57.24	19.48	0.93	0.00	49.20
November	41.89	23.14	1.43	15.34	67.98
December	47.44	32.73	2.36	14.82	126.07
AVERAGE	54.38	23.61	0.92	23.76	52.34

Table 2. Overview of average monthly values of the monitored parameters in the urban area of the city during 2019.

Month	SO ₂ (µg/m ³)	NO ₂ (µg/m ³)	CO (mg/m ³)	O ₃ (µg/m ³)	PM2.5 (µg/m ³)
January	47.30	35.04	1.24	23.69	69.06
February	38.67	32.31	1.34	28.18	71.17
March	37.58	29.62	1.15	42.09	39.84
April	29.63	24.08	0.00	46.28	32.66
May	27.36	20.10	0.00	46.48	18.65
June	50.20	16.80	0.00	55.65	23.15
July	53.74	14.60	0.00	0.00	19.51
August	67.67	15.34	0.00	0.00	20.16
September	58.30	16.87	0.00	0.00	24.91
Oktober	61.96	21.59	0.00	0.00	43.99
November	26.22	20.85	2.51	15.43	47.66
December	30.86	26.43	3.09	16.81	68.82
AVERAGE	44.12	22.80	0.78	22.88	39.96

Note: The bolded values represent the annual limits exceeded as regulated by the ordinance.

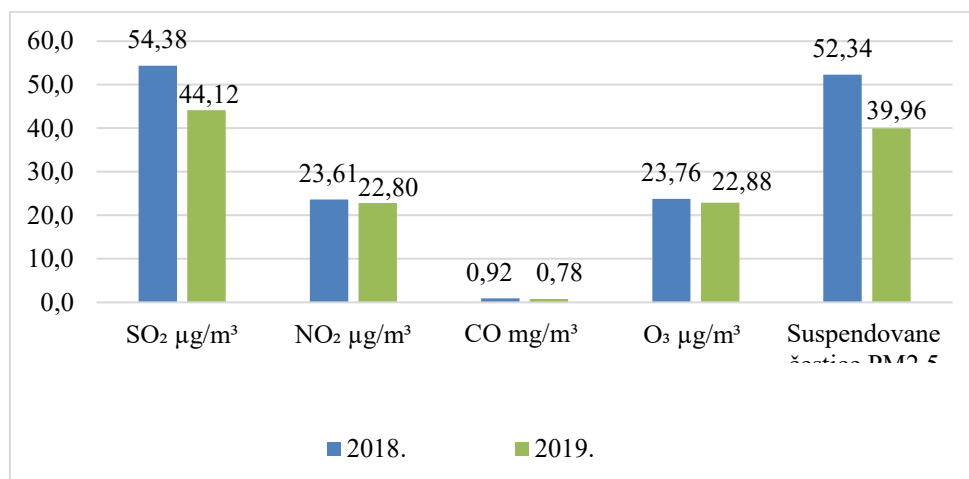


Figure 1. Comparison of average values of the monitored parameters during 2018 and 2019 in the urban area of the city of Lukavac

Air Quality in the Industrial Area

Measurements from the GIKIL (Figure 2, Figure 3) industrial site revealed consistently elevated pollutant concentrations. Annual average SO₂ levels in 2018 exceeded 350 µg/m³, significantly above the regulatory limit. Similar exceedances were observed for particulate matter, reaching up to 200 µg/m³. Hydrogen sulfide (H₂S) levels frequently surpassed permissible concentrations, contributing to characteristic odor nuisance and local complaints. Although nitrogen oxides were within permissible ranges, their persistence indicates ongoing

combustion-related emissions. Carbon monoxide concentrations fluctuated seasonally, showing higher levels during production peaks.

The persistence of high pollutant levels suggests that existing emission control systems (filters, scrubbers, and electrostatic precipitators) may be insufficiently maintained or outdated. This is consistent with the findings of the Center for Ecology and Energy Tuzla (2020), which identified Lukavac as one of the most polluted municipalities in Bosnia and Herzegovina.

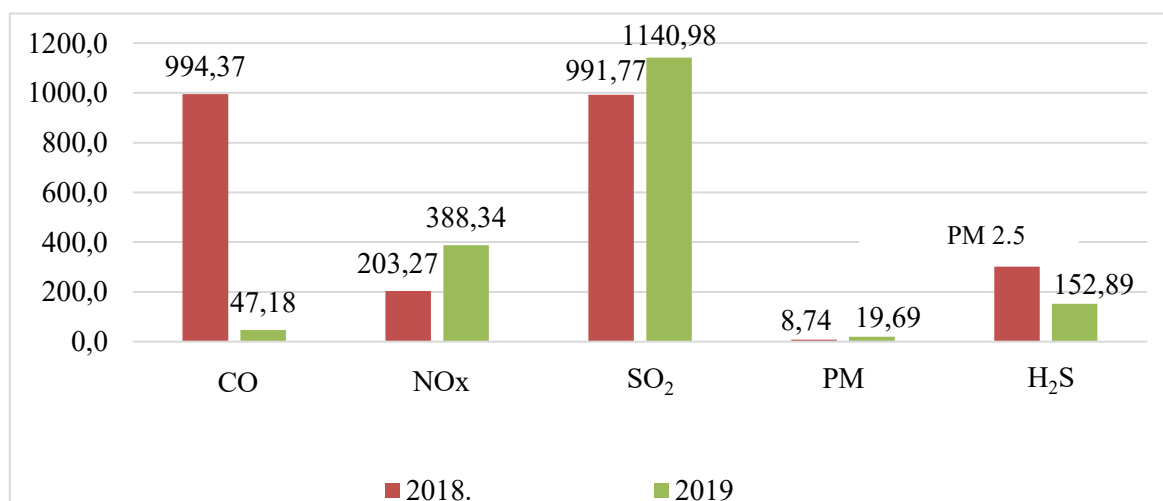


Figure 2. Presence of pollutants during 2018 and 2019 at the monitoring site *Fabrika Energana* (Boiler 1, Boiler 2, and Boiler 3)

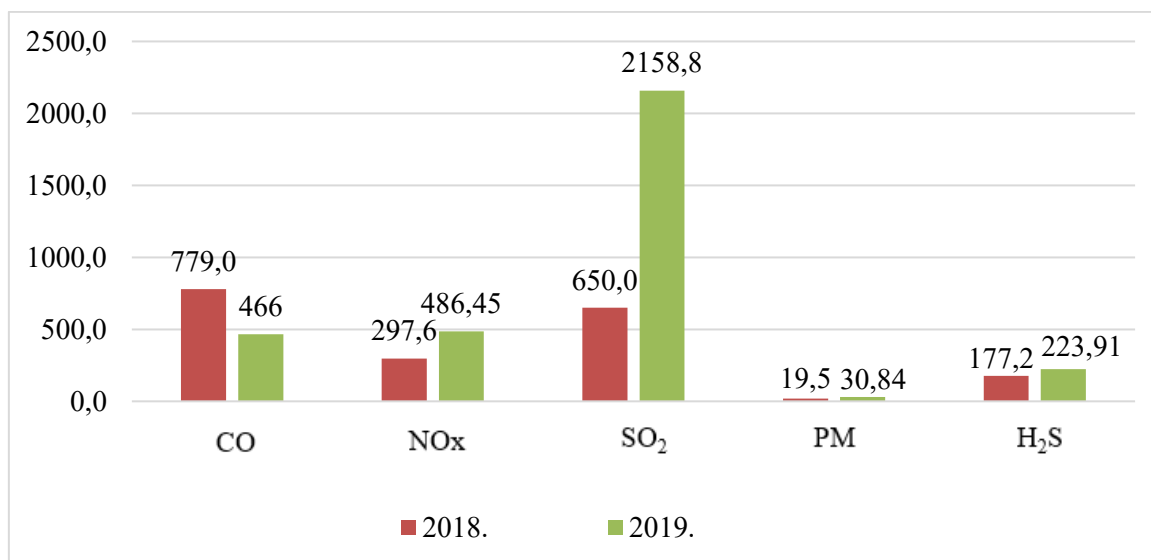


Figure 3. Presence of pollutant emissions during 2018 and 2019 at the monitoring site V Coke Battery (Coking Plant)

Seasonal and Meteorological Effects

During winter months, frequent temperature inversions and low wind speeds restrict vertical air dispersion, resulting in pollutant accumulation. These meteorological conditions are common in the Tuzla basin due to its topography, which traps pollutants in the lower atmosphere.

The correlation between ambient temperature and pollutant concentration was evident: as temperatures decreased, SO₂ and PM values increased. Conversely, ozone levels were higher in spring and summer due to increased sunlight and photochemical reactions involving NO_x and volatile organic compounds (VOCs).

Health and Environmental Implications

The high levels of particulate matter and sulfur compounds present serious risks to public health. Chronic exposure contributes to respiratory illnesses, such as asthma, bronchitis, and chronic obstructive pulmonary disease (COPD), as well as cardiovascular disorders. Epidemiological studies [5],[6] confirm a direct correlation between long-term exposure to PM_{2.5} and increased premature mortality.

The most vulnerable groups include children, the elderly, pregnant women, and industrial workers. Air pollution also impacts vegetation, soil acidification, and water quality through deposition of acidic and particulate materials.

From an environmental management perspective, the results highlight the need for stricter implementation of emission control measures and transition to cleaner technologies, particularly within the coke and cement industries.

CONCLUSION

This study confirms that both the urban and industrial parts of Lukavac experience high levels of air pollution, dominated by sulfur dioxide and particulate matter. Although nitrogen oxides and ozone occasionally remain within legal limits, the overall air quality frequently falls into "poor" or "very poor" categories according to the Air Quality Index. The persistence of elevated pollutant levels indicates a combination of industrial emissions, household heating with coal and wood, and inadequate air dispersion due to topographic and meteorological factors. The findings emphasize the urgent need for: Upgrading industrial emission control systems, promoting energy efficiency and cleaner fuels, expanding air quality monitoring networks, integrating public health surveillance with environmental monitoring. Improving air quality in Lukavac will require coordinated efforts among industry, government, and the local community. Further studies should include dispersion modeling, source apportionment, and health impact assessments to provide a scientific basis for sustainable environmental policy in Tuzla Canton.

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