

ANALYSIS OF THE ORIGIN OF AIR POLLUTION IN THE AREA ZENICA-DOBOJ CANTON

Vehid Birdahić, Muvedet Šišić, Nusret Imamović
University of Zenica, Faculty of Mechanical Engineering
Zenica, B&H

Halim Prcanović, Mirnes Duraković
University of Zenica, Institute “Kemal Kapetanović”
Zenica, B&H

Keywords: pollutants, emission sources, air quality.

ABSTRACT

The paper presents data on emissions of analyzed pollutants into the air (SO₂, NO_x, CO, VOC, NH₃, PM₁₀, PM_{2.5}, PAH, Pb, Cd, and Hg) by sector (industry and energy, small combustion plants, road traffic and services-agriculture and animal husbandry), and by cities and municipalities in the area of the Zenica-Doboj Canton. Based on the analyzed data, it was determined that the air quality in the area of the Zenica-Doboj Canton is very endangered and does not satisfy the prescribed legal regulations, which can potentially affect people's health, ecosystems, economic prosperity, and development. According to the results of the research, it was determined that the main causes of excessive air pollution are the production of emissions from industrial and energy plants, local boiler houses and home fireplaces, road traffic, and the service sector (agriculture, processing industry, construction, trade), as well as unfavorable climatic conditions, with the presence of inadequate topographical conditions and other influencing factors.

1. INTRODUCTION

Air quality is a very important problem for human health, the economy, development, and the environment. Excessively polluted air has a significant impact on people's health and leads to numerous diseases, thereby causing financial costs for treating the sick and eliminating the consequences. The economy is affected by costs for treatment and loss of productivity and the impact on the environment is reflected in large and often unpredictable pressures that affect the quality of water, soil, and ecosystems. Pollutants that worsen air quality and cause negative effects on receptors, as well as the effects of acidification, eutrophication, and photochemical pollution, are sulfur dioxide (SO₂), hydrogen sulfur (H₂S), nitrogen oxides (NO_x), suspended particles (PM₁₀ and PM_{2.5}), carbon monoxide (CO), ammonia (NH₃), ozone (O₃), volatile organic compounds (VOC), polycyclic aromatic hydrocarbons (PAH), sediment, heavy metals (Pb, Cd, Hg, and Fe). Air quality management includes a series of systemic measures aimed at ensuring air quality that will not cause ecological disturbances and consequences, and is based on measurements and assessments of emissions and air quality. The Zenica-Doboj Canton (Ze-do Canton) is located in the central part of Bosnia and Herzegovina, in the sub-basin of the Bosna river, it covers an area of 3,345 km² and ranks fourth in size in the Federation of BiH, and has favorable geotrafic and hydrographic characteristics, because it is located in the central part of Bosnia and Herzegovina, through which the river Bosna flows for the most part, and the route of the highway on corridor Vc, the main road M-17 and the railway line pass through [1]. By putting into operation integral production at the company

ArcelorMittal in Zenica, but also by the operation of other industrial and energy plants and facilities, such as the production of electricity in the Thermal Power Plant Kakanj (TE Kakanj), the production of thermal energy in numerous boiler houses, the production of packaging paper in "Natron Hayat" in Maglaj, leather processing in the company "Prevent-Leather" in Visoko, cement production in Kakanj, exploitation, and processing mineral raw materials, etc., as well as the development of road traffic, the use of a large number of small boiler houses and home fireplaces, the air quality in the area of the Zenica-Doboj Canton, above all in the cities located in the valley of the Bosna river, is highly threatened and does not meet the prescribed standards, which can potentially affect people's health, economy and development. The present high and often excessive emissions of harmful substances, as well as unfavorable climatic and topographical conditions result in exceeding the limit values of certain harmful substances in the air, especially SO₂, suspended particles, and other pollutants in certain parts of the Zenica-Doboj canton (Zenica, Kakanj, and Maglaj). Taking into account the above indicators, it is very important to approach the systematic planning of air quality management in a studious and comprehensive manner in regions where air quality is threatened and excessively polluted in order to achieve and maintain the prescribed air quality, protect human health, and develop this area.

2. MAIN SOURCES OF EMISSIONS RESPONSIBLE FOR AIR POLLUTION

The main emission sources and production potentials of the Zenica-Doboj Canton are concentrated in the energy, mining, and processing industry. In the structure of production, the processing industry participates with 45.41%, electricity, gas, and water supply with 34.77%, and mining with 19.82%. Likewise, a large number of small and medium-sized enterprises with the finalization of products in the metal and wood processing industry, exploitation and processing of mineral raw materials, and food technologies characterize the economy of the Zenica-Doboj Canton as a base-energy-raw material (coal-energy-metallurgy). According to the data from the Register of Plants and Pollution of the Zenica-Doboj Canton, the dominant sources of air pollutant emissions are [2]:

- Industrial plants (point sources): metallurgical industry, cement industry, leather processing industry, textile industry, paper, and cardboard industry, wood processing industry, metal processing industry;
- Energy plants (point sources): Thermal power plant Kakanj, Heating plant "Natron Hayat" Maglaj, Heating plant in ArcelorMittal Zenica, Heating plant Tešanj, Heating plant Žepče, Heating plant Zavidovići, heating plants in the production complex "Prevent" Visoko;
- Small fireplaces where solid fuel is dominantly used;
- Traffic (road and rail);
- Service sector (agriculture, processing industry, construction, wholesale and retail trade, information and communications).

The database on pollutant emissions into the air was formed on the basis of the field collection of data on emissions from all identified sources by the project team for the purpose of establishing the Registry on plants and pollution in the Zenica-Doboj Canton. The database on emissions was formed by sector in order to analyze sectorial impacts on air quality. Figure 1 shows the dominant sources of air pollutant emissions in the Zenica Doboj Canton, which have the greatest impact on air pollution.

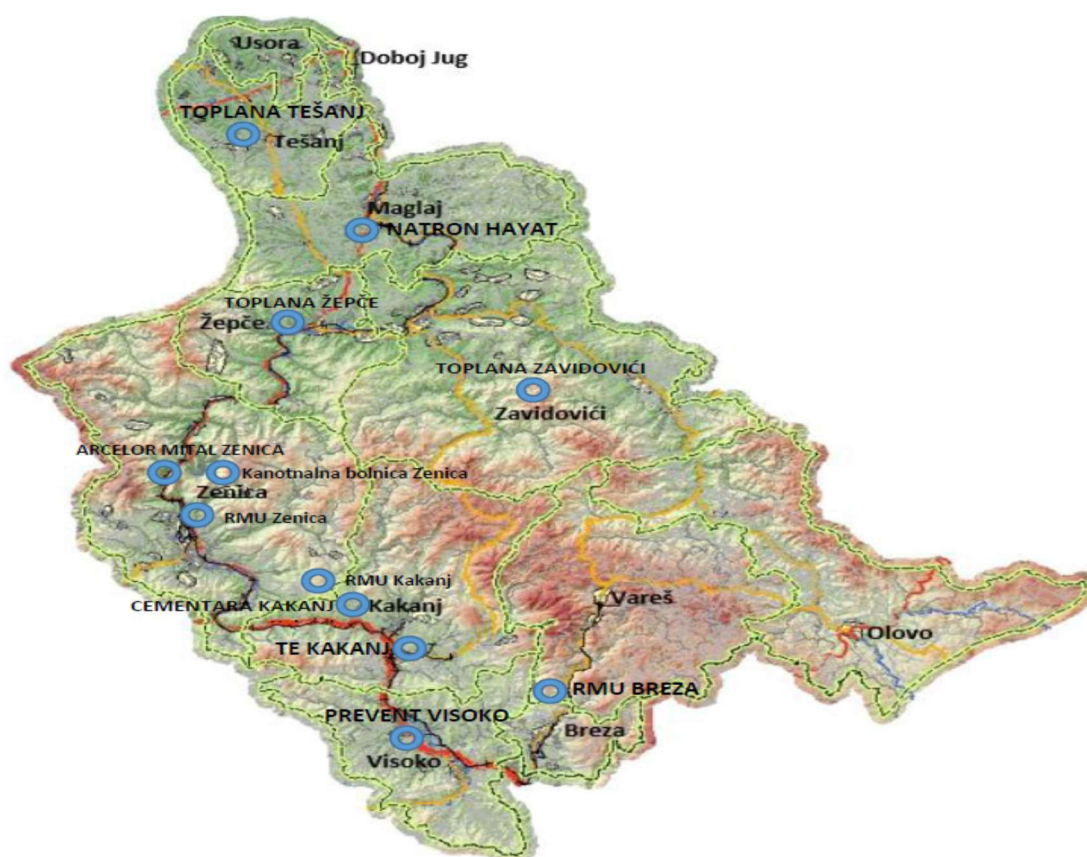


Figure 1. Dominant sources of air pollutant emissions in the area of Ze-do Canton [2]

3. TOTAL QUANTITY OF EMISSIONS FROM REGISTERED SOURCES

Data on the emission of pollutants into the air (SO₂, NO_x, CO, VOC, NH₃, PM₁₀, PM_{2.5}, BC, PAH, Pb, Cd, and Hg) in the area of the Zenica-Doboj Canton were taken from the database of the Register of Plants and Pollution in the Zenica-Doboj Canton. of the Doboj canton, which is run by the Center for the Environment at the "Kemal Kapetanović" Institute in Zenica. Air pollutant emissions from industrial and energy plants as dominant sources of pollution in the area of Ze-do Canton are shown in Table 1.

Table 1. Emissions of industrial and energy plants in the area of Ze-do Canton [2]

City/Municipality	SO ₂ (kt)	NO ₂ (kt)	VOC (kt)	CO (kt)	NH ₃ (kt)	PM ₁₀ (kt)	PM _{2.5} (kt)	BC (kt)	Pb (t)	Cd (t)	Hg (t)	PCDD/ PCDF (gI-TEQ)	PAH (t)	PCB (kg)
Zenica	4,84	1,25	0,22	1,39	0	1,68	1,17	0,06	6,36	0,0	0,16	12,09	2,69	11,06
Kakanj	69,87	7,33	0,10	0,54	0	0,17	0,21	0,07	0,31	0,03	0,05	0,44	2,36	7,67
Maglaj	1,38	0,38	3,02	9,49	0,04	0,12	0,11	5,2	0,39	0,02	0,03	0,79	2,27	11,46
Zavidovići	0,002	0	0,01	0,00	0	0,05	0,00	0	0,00	0,00	0,00	0,00	0,00	6,92
Total	76,10	8,97	3,36	11,43	0,04	2,041	1,515	5,34	7,07	0,06	0,25	13,33	7,34	37,10

A significant source of air pollution is also small fireplaces and local boiler houses, for which Table 2 shows the share of emissions from small fireplaces by local communities in the area of the Zenica-Doboj Canton, which shows that the largest share of pollutant

emissions is in the area of the City of Zenica as the seat of the canton, which is understandable because Zenica is the largest urban industrial center.

Table 2. Overview of the share of pollutant emissions from small furnaces into the air by local communities in the area of the Zenica-Doboj Canton [2]

City/Municipality	Participation SO ₂ %	Participation CO %	Participation PAH %
Zenica	38%	35%	37%
Maglaj	9%	9%	9%
Visoko	8%	9%	8%
Tešanj	9%	10%	9%
Kakanj	3%	3%	3%
Other municipalities	33%	34%	34%

Analyzing data on the balance of pollutant emissions from various sources of pollution, the following was determined: Emissions from energy and industrial plants are by far the largest compared to other sectors, with a total of 76,103 t/y SO₂, 8,976 t/y NO_x, 3,365 t/y VOC, 2,041 t/y of PM₁₀ and 1,515 t/y of PM_{2.5} (Figure 2). Emissions from small boiler houses and domestic fireplaces follow in terms of quantity, second in relation to energy and industrial plants, and amount to a total of 8,070 t/y SO₂, 724 t/y NO_x, 3,399 t/y VOC, 3,860 t/y PM₁₀ and 3,713 t/y g PM_{2.5}, as shown in Figure 3 [3].

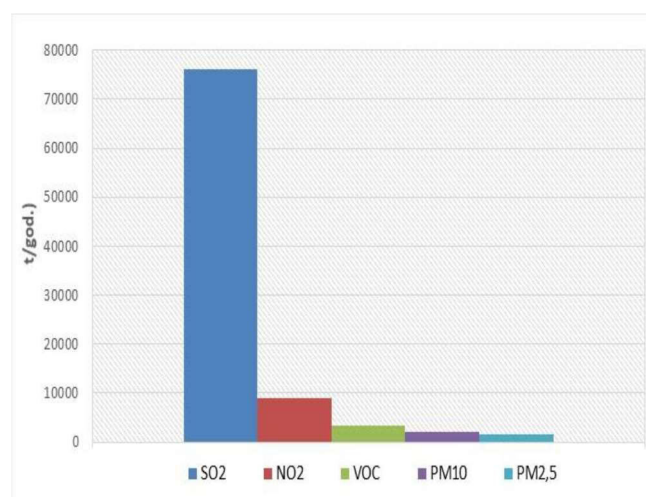


Figure 2. Energy and industrial emissions facilities in the area of Ze-do canton[1,2]

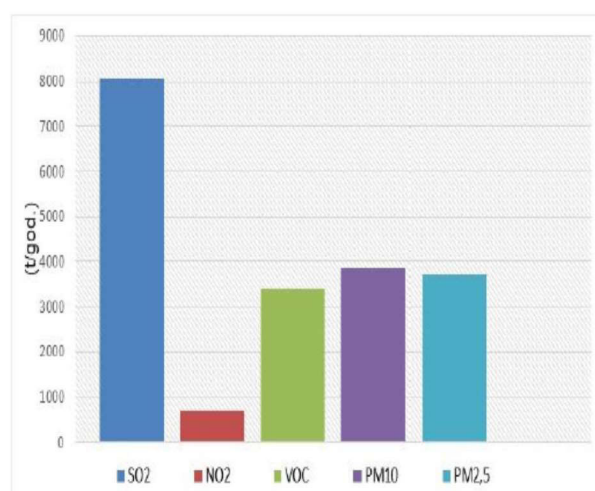


Figure 3. Emissions from small boilers and home fireplaces in the area of Ze-do canton [1,2]

According to the produced emissions from road traffic by quantity, it was determined that they are in third place in relation to the energy and industry sector and amount to 62 t/y SO₂, 1260 t/y NO_x, 312 t/y VOC, 146 t/y PM₁₀ and 120 t/y of PM_{2.5}, which are given in Figure 4.

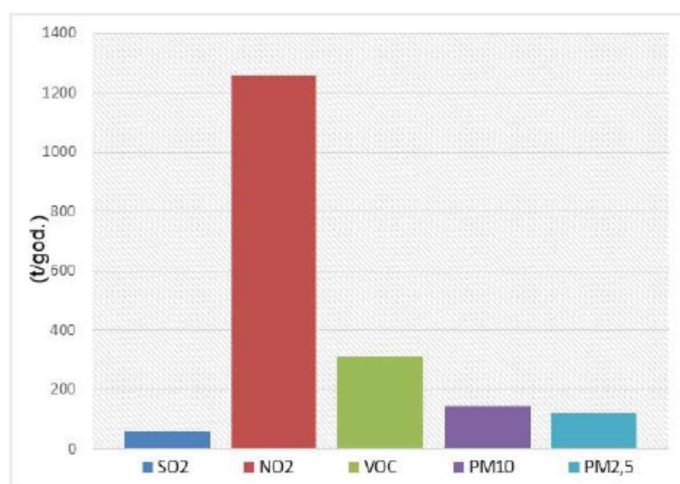


Figure 4. Emission of road traffic in the area of Ze-do canton [1,3]

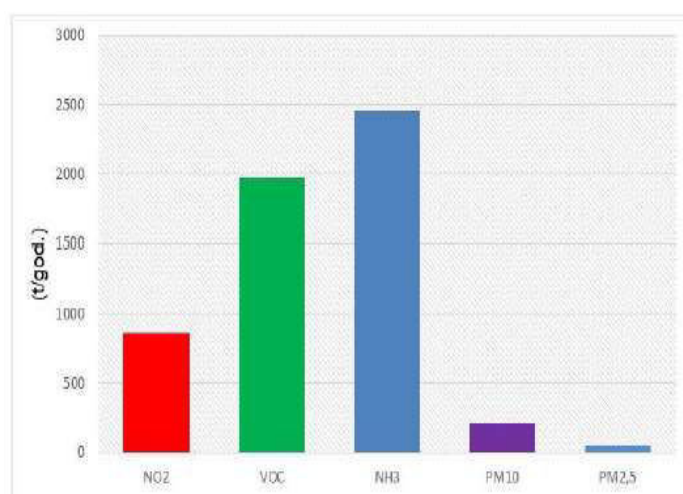


Figure 5. Emission of the service sector (agriculture-livestock) [1,3]

Emissions from the service sector (agriculture-livestock) total: 863 t/y NO_x, 1959 t/y VOC, 2467 t/y NH₃, 214.5 t/y PM₁₀, and 45 t/y PM_{2.5}, which are shown in Figure 5.

By combining all relevant data on total emissions, Table 3 shows the total emissions for the entire area of the Ze-do Canton, where the largest SO₂ emission is evident in the amount of 84,195 kt.

Table 3. Overview of total emissions in the area of the Zenica-Doboj Canton [2]

SO ₂ (kt)	NO ₂ (kt)	VOC (kt)	NH ₃ (kt)	PM ₁₀ (kt)	PM _{2.5} (kt)	BC (kt)	CO (kt)	Pb (t)	Cd (t)	Hg (t)	PAH _s (t)
84,195	12,373	12,818	3,222	7,199	5,513	5,776	37,358	9,881	0,123	0,274	11,628

3.1. Data on pollution that came from other regions/areas

Due to its geographical location and atmospheric circulation, the canton is exposed to the influence of pollution coming from the Tuzla region due to the presence of high emission sources (TE Tuzla and Gikil d.o.o. Lukavac), whose dominant sources are more than 40 km away from the area of the Zenica-Doboj canton as the crow flies. Likewise, due to the general circulation of the atmosphere, this area is exposed to the influence of cross-border transport of particles and particle precursors from distant industrially developed countries, which are significant sources of particle precursor emissions. Modeling estimated that approx. 20-40% of emitted polluting substances from TE Kakanj dissipate outside the area of the Zenica-Doboj Canton, which depends on the general circulation of the atmosphere and meteorological conditions [1,2].

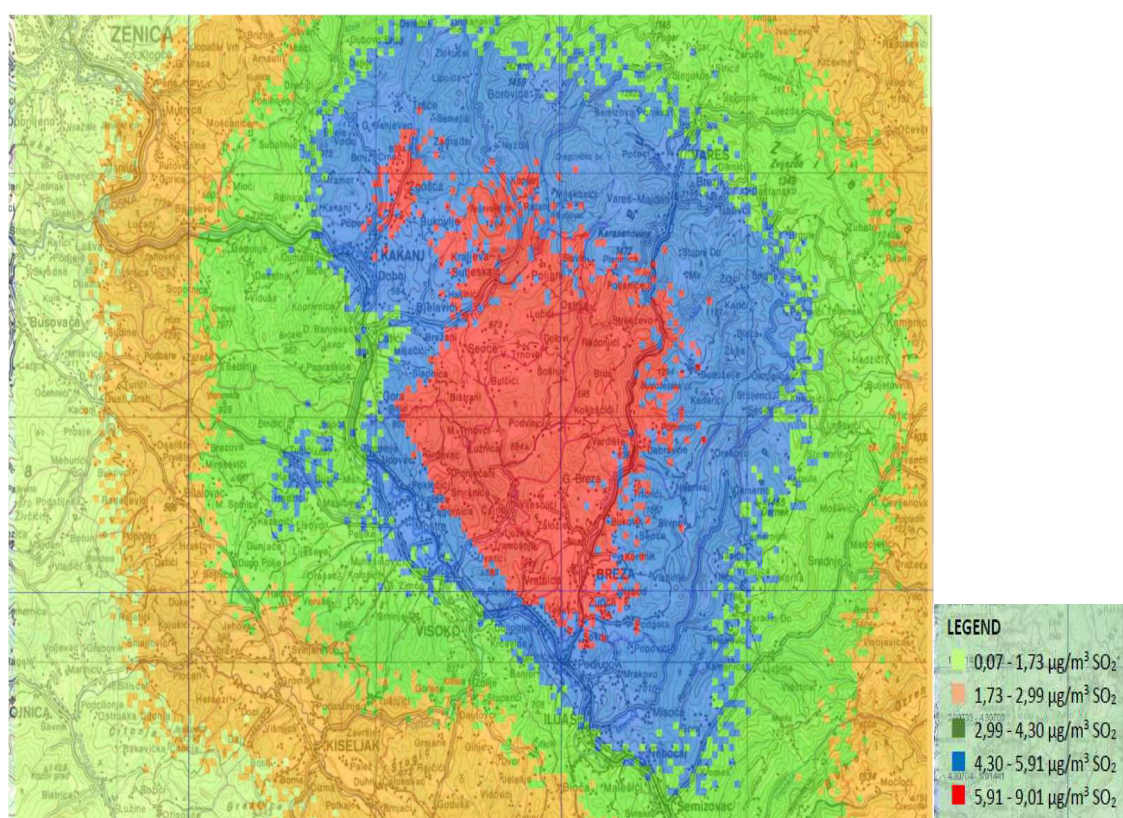


Figure 6. Dispersion of SO₂ emitted from the tall chimney of the TE Kakanj [1]

4. CONCLUSION

According to the results presented in this paper, it can be concluded that the origin of pollutant emissions by sector in the area of the Zenica-Doboj Canton is as follows:

- SO₂ emissions show that energy and industrial plants are by far the largest sources of emissions of this pollutant with a share of 90.35 %, followed by small boiler houses and home fireplaces with 9.58%, while SO₂ emissions from road traffic are negligible (0.07%).
- PM₁₀ emissions show that small combustion plants are the largest sources of emissions of this pollutant with 61.65 %, followed by energy and industrial plants with 3.60%, while the agriculture sector has significantly fewer emissions with 3.42%, and traffic emissions are the smallest at 2.33% of PM₁₀.
- The emission of PM_{2.5} shows that small boilers and home fireplaces are the biggest sources of emissions of this pollutant with a share of 68,8 %, followed by energy and

industrial plants with a share of 28.09%, while traffic emissions have a much smaller share with 2.23% of PM_{2.5}, and emissions from the agriculture sector are very small with a share of 0.83%.

- The contribution of different emission sources to air pollution does not depend only on the number of substances emitted into the air, but also on the location of the emission source, and emission conditions, such as chimney height, flue gas velocity, flue gas temperature, and atmospheric circulation and relief conditions as well as dispersion conditions.
- The air quality in Ze-do Canton, in addition to the present pollutant emissions, is significantly affected by unfavorable meteorological and topographical conditions, because the atmosphere, given its volume and dynamics, tolerates a certain amount of polluting substances and gradually dilutes them through the processes of dispersion and chemical transformation.
- Improving the quality of air can only be achieved with an integrated approach to all subjects by consistently harmonizing all sectoral policies. For this reason, the mobilization and synergy of all entities are necessary, starting from business entities whose facilities excessively pollute the air, local self-government units, and the Zenica-Doboj Canton to the Government and competent ministries of the Federation of Bosnia and Herzegovina, to create the necessary conditions for the implementation of measures and projects to achieve the planned improvement air quality in order to protect the health of the population, ensuring the conditions for a healthy life and coordinated development with social and ecological conditions.

5. REFERENCES

- [1] Kantonalni akcioni plan za poboljšanje i zaštitu kvaliteta zraka na području Zeničko-dobojskog kantona, JU Univerzitet u Zenici, Metalurški institut “Kemal Kapetanović” Zenica, 2020.
- [2] Registar o postrojenjima i zagađivanjima na području Zeničko-dobojskog kantona, Metalurški institut “Kemal Kapetanović” Zenica, 2019.
- [3] Izvještaj o rezultatima mjerenja zagađenosti zraka u Zenici za period juli-novembar 2019. godine (Izvještaj sa automatskih stacionarnih mjernih stanica), JU Univerzitet u Zenici, OJ Institut “Kemal Kapetanović” u Zenici, 2019.