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29 MAY - 01 JUNE 2024

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CONTENT
SADRŽAJ

EVALUATING SERBIAN AIR QUALITY INITIATIVES IN A REGIONAL CONTEXT

Filip Nastić[1], Davor Končalović[1], Vladimir Vukašinović[1], Nebojša Jurišević[1], Jelena Nikolić[1], Dubravka Živković[1]
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Aspirations towards development and modernization of life caused a problem that engulfed the whole world – air pollution. A growing number of recent research indicate the negative influence of air pollution on the environment, economy, human health, and life quality. Consequently, responsible bodies of the European Union and European countries have implemented a series of air quality policies and strategies. This paper includes a review of the World Health Organization air quality guidelines, The Clean Air Package published by the European Commission, and action plans published by the responsible bodies of Western Balkan (Croatia, Serbia, and North Macedonia) and Central Europe countries (Austria and Germany). Based on the collected data, a comparison of action plans and air quality trends was made, mainly with an emphasis on the situation in the Republic of Serbia.

Keywords: *air pollution, environment, human health, life quality*

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1. INTRODUCTION

Habits of the modern population caused an exponential decrease in air quality in the last few years, consequently, growing one of the biggest problems facing modern urban communities – air pollution. According to the World Health Organization (WHO), air pollution is associated with around 6.7 million premature deaths annually [1]. Air pollution is causing cancer [2], cardiovascular [3], pulmonary [4], and neurological [5] diseases, thus, disrupting the life quality and reducing global overall life expectancy [6]. Besides the effect on human health, air pollution has significant environmental effects such are acid rains, haze, ground-level ozone, global climate change, wildlife endangerment, eutrophication[1], etc. [7].

To mitigate air pollution, legislative bodies are publishing policies and strategies as guidelines. Overall, better air quality can be achieved by [8]:

i. Keeping the concentrations of air pollutants at or below maximum permitted levels;
ii. Reducing the concentrations of pollutants that exceed their maximum permitted levels.

[1] Disequality of aquatic diversity caused by the stimulation of algae blooming under higher concentrations of nutrients.

Air quality monitoring is a requirement for an air quality management system. It gives insight into the intensity of air pollution and its composition and toxicity [8]. Larssen et al. stated that the monitoring system objectives are defining the design and operation of monitoring networks [9]:

i. Compliance monitoring - supports the air quality directives;
ii. Air quality surveillance monitoring – describes the air quality in the monitored area, state, or continent;
iii. Exposure assessment monitoring – defines the air pollution harm to health, vegetation, and materials;
iv. On-line monitoring – designed to predict high-concentration incidents;
v. Operational monitoring – designed to observe the air quality around specific sources
vi. Monitoring programmes to support scientific research.

The fight against air pollution requires a lot of techno-economic efforts which could be a problem for communities with lower life standards and/or level of development. According to the World Bank [10] around 64.5 percent of people in lower-middle-income countries are exposed to higher $PM_{2.5}$ levels (over 35 $\mu g/m^3$), compared to 4.4 percent in low-income and 0.9 percent in high-income countries. Additionally, Jiang et al. stated that the growth of GDP per capita is positively correlated with emissions per capita [11]. Overall, these statements indicate that developing countries which make up around 85% of the world's population are struggling with intensive air pollution due to aspirations towards development and at the same time not having enough resources or willingness to face this problem.

The Western Balkans consist of Albania, Bosnia and Herzegovina, Croatia, North Macedonia, Montenegro, Kosovo, and Serbia. According to the International Monetary Fund, all mentioned countries except Croatia are developing countries. This paper includes a review of World Health Organization air quality guidelines, The Clean Air Package published by the European Commission, and action plans published by the responsible bodies of Wester Balkan (Croatia, Serbia, and North Macedonia) and Central Europe countries (Austria and Germany). Based on the collected data, a comparison of action plans and air quality trends was made often through comparison with legislation and initiatives in the Republic of Serbia.

2. WORLD HEALTH ORGANIZATION AIR QUALITY GUIDELINES

The World Health Organization defined a global target for national, regional, and city communities to improve air quality, consequently, improving the health of their citizens. Generally, those guidelines are a set of recommended limit values for each air pollutant [12]. Table 1 shows the recommended 2021 air quality guidelines set by the World Health Organization.

Table 2. *World Health Organization guidelines for 2021*

Pollutant	$PM_{2.5}$ [$\mu g/m^3$]		PM_{10} [$\mu g/m^3$]		O_3 [$\mu g/m^3$]		NO_2 [$\mu g/m^3$]		SO_2 [$\mu g/m^3$]	CO [mg/m^3]
Averaging time	*Annual*	*Daily*	*Annual*	*Daily*	*Peak season*[1]	*8-hour*	*Annual*	*Daily*	*Daily*	*Daily*
Guideline	*5*	*15*	*15*	*45*	*60*	*100*	*10*	*25*	*40*	*4*

To describe the current state of air quality in the Western Balkans, Fig. 1 includes the comparison of annual average concentrations for 2021 for Western Balkan countries with the World Health Organization's guidelines (black limit line).

[1] „Average of daily maximum 8-hour mean O_3 concentration in the six consecutive months with the highest six-month running-average concentration [12].“
[3] ISO 3166-1 alpha 3 codes
[4] The 1999 Gothenburg Protocol to abate acidification, eutrophication, and ground-level ozone.

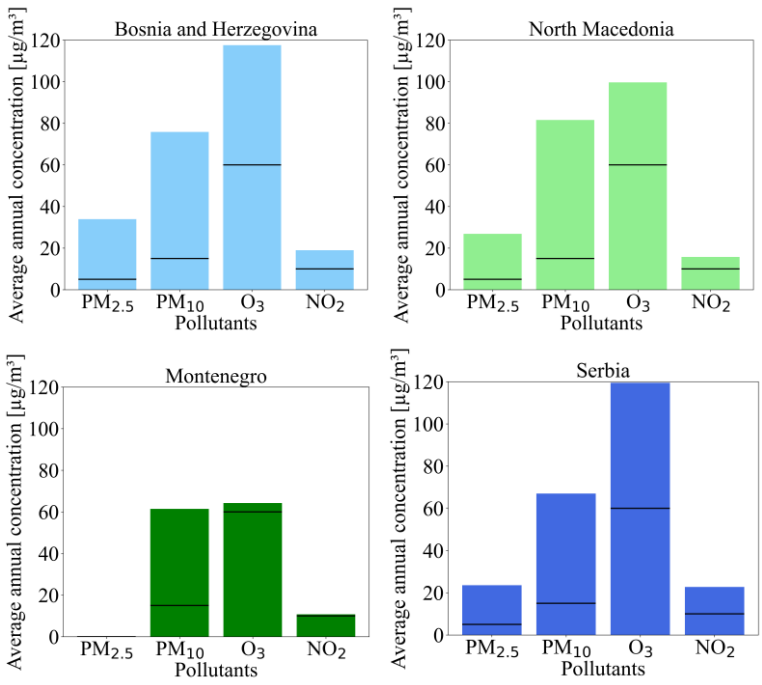

Fig. 8. *Average annual concentrations per country of Western Balkan [13]*

By comparing average annual concentrations of pollutants for Western Balkan countries, it can be noticed that each country is drastically exceeding WHO-given guidelines indicating the air quality crisis happening in this region.

3. THE CLEAN AIR PACKAGE: IMPROVING EUROPE'S AIR QUALITY

The National Emission Ceilings (NEC) Directive is the main tool for achieving air quality targets. The extended deadline for the NEC Directive is set for 2030, with two important checkpoints: 2020 - setting/updating obligations set under the Gothenburg Protocol[1]; and 2025 – setting incidental goals to stay on the pathway towards 2030 obligations. This directive is focused on four original air pollutants (SO_2, NO_x, non-methane VOCs, and NH_3) and two new ($PM_{2.5}$ and CH_4) by proposing obligations for them. Besides the flexibility offered by the NEC Directive, many governments request support via EU source controls. EU source measures should help to achieve the requested reductions (ranging from 57% reduction for VOCs to 72% for NO_x) [13]:

i. The Ecodesign Directive focused on domestic combustion;
ii. The Industrial Emissions Directive (IED) strives to develop the Best Available Technologies (BAT) conclusions for main industrial sources, in particular, combustion plants over 50 MW;

iii. Revision of the Non-Road Mobile Machinery Directive which will cover a wider range of machinery and coordinate the controls with the Euro VI heavy-duty limits.

Important sources of pollution that are not effectively controlled due to the gap in EU source legislation are the thermal capacities between 1 and 50 MW. Thus, the European Commission proposed a Directive on Medium Combustion Plants (MCP) which will provide an effective tool to reduce the emissions of NO_x, SO_2, and PM. It is estimated that this directive will lead to significant emission reductions in most of the member states. Ammonia is another pollutant included in the NEC directive with a requested reduction of 27%. Most of the ammonia is emitted during agricultural activities, and the directive provides a set of measures that are cost-effective even for smaller farms. Additional support is provided to member states by Rural Development Funds. To group the current working strands[1] and to promote activities considering air quality and the environment in the farming community European Commission will establish an agriculture platform as a part of the European Clean Air Forum.

The sulfur emissions from shipping in the EU are ensured by the revised Directive on the Sulphur Content of Liquid Fuels (2012), however, the air quality on land will be still affected by shipping. Shipping should be controlled and developed at the international level considering its global significance. The proposal is that a revised NEC Directive should aim to induce emissions reductions from shipping by allowing them to be offset against the obligations for 2025 and 2030 [13].

Another aspiration of the European Union has been addressed to the non-EU parties. Considering the economic status of the third countries, they are a critical group that has a significant influence on air pollution. The plan is that the European Commission will continue to engage with Eastern Europe, Caucasus and Central Asia (EECCA) states to implement the Gothenburg Protocol, promote the green economy, and provide financial support. Important steps towards better air quality are innovations and research. The EU's research and innovation programme for 2014 to 2020 (Horizon 2020) generally strives for the reduction of health and environmental consequences caused by exceeding air pollution [13].

European Environmental Agency (EEA) published a report considering the status of the NEC Directive in 2022. The report shows that [14]:

- In 2020, 13 countries achieved their 2020-2029 emission reduction commitments for five main pollutants;
- However, 14 countries failed to achieve the set goals for at least one pollutant;
- Ammonia is currently the biggest challenge for the period 2020-2029 with 11 states that need to cut their emissions;
- Emission of sulfur dioxide achieved the highest reduction, with only one state not meeting the commitment;

[1] NEC Directive, the UNECE Ammonia Guidance Document, the increasing focus in the Common Agricultural Policy on environmental protection, and the co-benefits of air pollution control for climate, water, and soil.

- Two member states have already met their commitments for 2030 and beyond;
- Around 60% of member states will need to reduce emissions of ammonia, nitrogen oxides, and fine particulate matter to meet the commitments set for 2030.

Figure 2 shows the status of European Union member states from the aspect of emission reduction commitments. The diagram shows the number of states that met their 2020-2029 commitments, the number of states that need a reduction under 10% to meet their 2020-2029 commitments, the number of states that need the reduction between 10 and 30% to meet their 2020-2029 commitments, and number of states that need the reduction between 30 and 50% to meet their 2020-2029 commitments.

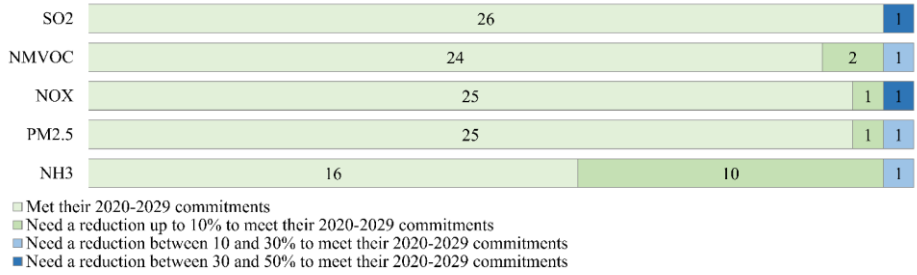

Fig. 9. *European Union member states status following the NEC directive*

Figure 3 analyses the success of each European Union country from the aspect of meeting the 2030 commitments defined by the NEC Directive. There are a few member states that already met the 2030 commitments (Belgium and Estonia), and countries that are close to achieving their goals set for 2030 (Finland, Greece, and Slovakia).

Country	NH_3	*NMVOC*	NO_X	$PM_{2.5}$	SO_2	*Country*	NH_3	*NMVOC*	NO_X	$PM_{2.5}$	SO_2
Austria	●	✓	●	●	✓	*Italy*	●	●	●	●	✓
Belgium	✓	✓	✓	✓	✓	*Latvia*	●	✓	✓	●	✓
Bulgaria	●	●	✓	●	✓	*Lithuania*	●	●	●	●	✓
Croatia	●	●	●	●	✓	*Luxembourg*	●	✓	●	✓	✓
Cyprus	●	✓	●	●	●	*Malta*	✓	✓	●	●	✓
Czechia	●	●	●	●	✓	*Netherlands*	●	●	●	✓	✓
Denmark	●	✓	●	●	✓	*Poland*	●	●	●	●	●
Estonia	✓	✓	✓	✓	✓	*Portugal*	●	●	●	●	✓
Finland	✓	●	✓	✓	✓	*Romania*	●	●	●	●	✓
France	●	✓	●	●	✓	*Slovakia*	●	✓	✓	✓	✓
Germany	●	✓	●	●	●	*Slovenia*	●	●	●	●	●
Greece	✓	✓	✓	●	✓	*Spain*	●	●	●	●	✓
Hungary	●	●	●	●	●	*Sweden*	●	✓	●	✓	✓
Ireland	●	●	●	●	✓						

✓ Met their 2030 commitments
● Need a reduction of up to 10% to their 2030 commitments
● Need a reduction of 10 – 30% to their 2030 commitments
● Need a reduction of 30 to 50% to their 2030 commitments
● Need a reduction of more than 50% to their 2030 commitments

Fig. 10. *Succes of each EU member state from the aspect of meeting the 2030 commitments [14]*

5. RESULTS AND DISCUSSION

By comparing the action plans of Serbia (Belgrade), Croatia (Zagreb), North Macedonia (Skopje), Austria (Vienna), and Germany (Berlin) (Table 2), it is noticeable that they are very similar on paper. However, according to the trends of mean annual PM_{10} concentrations (Figure 4), Serbia (Belgrade) significantly lags behind Croatia (Zagreb), Austria (Vienna), and Germany (Berlin) in the realization of the plan. North Macedonia (Skopje) has a strong downward pollution trend. Figure 4 indicates that all countries (except North Macedonia) were tentatively in the same starting position (2017 and 2018), Zagreb, Vienna, and Berlin achieved better air quality with a dominant downward pollution trend, while air quality in Belgrade worsened with a stochastic (upward) pollution trend.

Table 3. *A comparative analysis of air quality plans*

(● – measure exists; ● – similar measure exists; ● – measure does not exist)

Measure	*Serbia*	*Western Balkans*		*Central Europe*	
	Belgrade [15]	*Zagreb* [16]	*Skopje* [17]	*Vienna* [18]	*Berlin* [19]
Urban planning measures					
Pollution-sensitive urban planning	●	●	●	●	●
Street greening	●	●	●	●	●
Transport measures					
Low emission zones	●	●	●	●	●
Promotion of eco-friendly vehicles	●	●	●	●	●

Development of electric vehicle infrastructure	🟢	🟡	🔴	🔴	🟢
Clean vehicles in the city enterprises	🟢	🟢	🟢	🟢	🟢
Old diesel vehicle retrofitting	🔴	🔴	🔴	🔴	🟢
Emission reduction of heavy diesel vehicles	🔴	🟢	🔴	🟢	🟢
Traffic stabilization	🔴	🟢	🔴	🟢	🟢
Speed limit lowering	🔴	🔴	🔴	🟢	🟢
Pollution-sensitive traffic management	🟡	🟢	🟢	🟢	🟢
Pollution-sensitive organization of coach traffic	🔴	🔴	🔴	🔴	🟢
Promotion of public transport	🟢	🟢	🟢	🟢	🟢
Promotion of walking and cycling	🟢	🟢	🟢	🟢	🟢
Organization of parking areas	🔴	🟢	🟢	🔴	🟢
Promotion of car-sharing	🔴	🟢	🔴	🔴	🟢
Promotion of eco-drive		🟢			
Rehabilitation of damaged roads	🔴	🔴	🔴	🔴	🟢
Extension of rail passenger transport lines	🟢	🔴	🔴	🔴	🟢
Heating, cooling, and energy production measures					
Increasing the energy efficiency of buildings	🟢	🟢	🟢	🟢	🟢
Clean heating energy	🟢	🟢	🟢	🟢	🟢
Reduction of small combustion plant emissions	🟢	🔴	🟡	🔴	🟢
Installation of mini-combined power plants	🔴	🔴	🟡	🔴	🟢
Campaigns for the proper use of wood stoves	🔴	🟢	🟢	🟢	🔴
Other measures					
Particle filters for construction machines	🔴	🔴	🔴	🟢	🟢
Fugitive dust emissions reduction	🔴	🔴	🔴	🔴	🟢
Emission reduction of industry	🟢	🔴	🟢	🟡	🟢
Air quality monitoring system modernization	🟢	🟢	🔴	🔴	🔴
Household and traffic emissions cadaster	🔴	🟢	🔴	🔴	🔴
Development of pollution maps	🔴	🟢	🔴	🔴	🔴

Mobile measuring stations air quality control	🔴	🟢	🔴	🔴	🔴
More-frequent street cleaning	🟢	🔴	🔴	🔴	🔴
Emission reduction from municipal waste treatment	🟢	🔴	🟢	🔴	🔴
Reduction in agricultural emissions	🔴	🔴	🔴	🟢	🔴

According to the mathematical interpretations of pollution trendlines (Fig. 4) Table 3 shows the estimated mean annual PM_{10} concentrations in 2030, and the year of reaching the WHO set limit for each country provided that the pollutant emission reduction trend continues exactly at this observed pace.

Table 4. *Estimated mean annual PM10 concentrations in 2030, and the year of reaching the WHO set limit for each country*

City	**Mathematical interpretation of the trendline (X – number of years starting from 2018 as baseline)**	**Estimated mean annual PM_{10} concentration for 2030**	**Year of reaching the WHO set limit for PM_{10}**
Zagreb	$Y = -1.5648 \cdot X + 20.937$	2.16	2021
Vienna	$Y = -1.0022 \cdot X + 20.322$	8.29	2023
Berlin	$Y = -0.6339 \cdot X + 16.129$	8.52	2019
Belgrade	$Y = 0.6402 \cdot X + 20.967$	28.65 (higher than now)	never
Skopje	$Y = -1.6106 \cdot X + 43.006$	23.67	2035

Out of all the analyzed cities, only Belgrade has a strong growth trend (visible also in Fig. 4). This indicates that, without any significant change, the air quality in Belgrade will worsen over time, and that Belgrade will never reach the WHO set limit for PM_{10} concentrations.

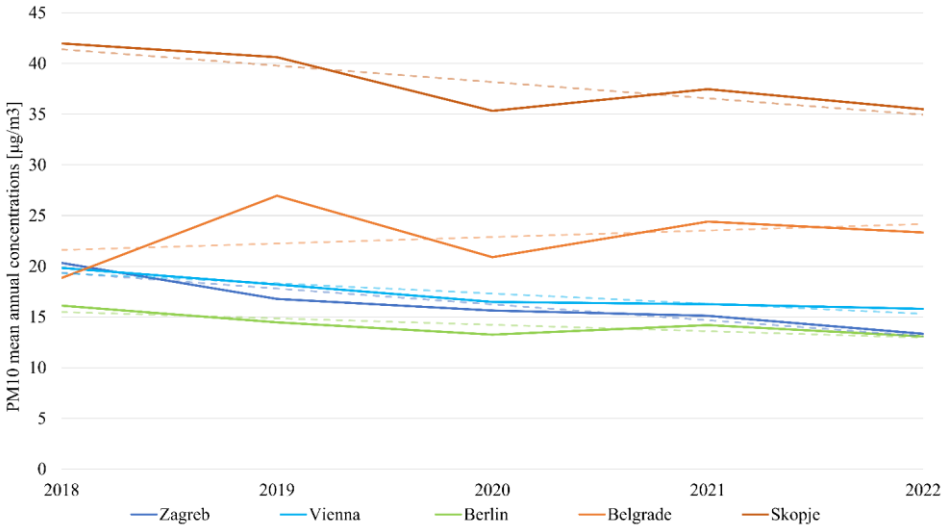

Fig. 11. *Mean annual PM_{10} concentrations for Zagreb, Belgrade, and Vienna*

According to the analysis of the implementation of the air quality plan for the city of Belgrade [15]: i) the cargo and delivery vehicles ban was not implemented because this measure, according to the government, is not a necessary ii) The pollution forecasting system was established but without the possibility to determine for what location the predictions were made; iii) electric and natural gas-powered buses were purchased, but the following infrastructure was built in only one location; iv) the domestic heating sector emission reduction plan has not even entered the starting phase (data collection and feasibility study); v) the instruction for shutting down of boiler plants, connection to the district heating, and transition to less-polluting fuels were introduced in 2023; vi) municipal waste burning inspections were introduced for few locations, but not for the whole territory of the city; vii) industry emission data is still unavailable for public; viii) study on the necessity and possibility of realization for the introduction and expansion of „30 km/h“ zones has not been done; ix) measure considering the reconstruction of bigger thermal plants is not defined clearly, for now only one plant was reconstructed TP „Cerak“ with estimated NO_X reduction of 30%.

6. CONCLUSION

Overall, the current situation in Serbia suggests that the government is not prioritizing the air quality plan. Furthermore, not only are there no visible steps towards effective improvement of air quality, but, as shown in Figure 4, there is not even enough effort to prevent further worsening and deepening of problems related to air quality. The long-lasting trend of the increased concentration of suspended particles has resulted in a pessimistic attitude of citizens and the impression that accumulated problems can no longer be solved. In this sense, any progress is, in the first place, a much-needed sign to citizens that negative trends can be reversed to the benefit of everyone.

In terms of the aforementioned, the air quality plan needs a deep revision that will define goals more clearly, introduce quantitative indicators to monitor the plan realization and determine the sources of funds that will be effectively used to achieve quicker and more efficient measure results.

In the current situation, the Republic of Serbia is in a situation where this type of cooperation between the government and citizens either does not exist or exists only as a form to be fulfilled. The consequence of the current situation is the polarization of attitudes, in which the government more and more often defends its (indefensible) positions, and the citizens feel as if no one is hearing them. So, the part that could/should be implemented, regardless of the legislation, relates to the necessity of joint work with citizens. The understanding and respecting of their positions/views is needed, especially of those who are most committed to problems related to air quality, while at the same time helping and strengthening the awareness of those who are still not sufficiently informed about the importance of air quality for the general welfare of the environment.

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