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COMPARATIVE STUDY ON AIR QUALITY IN EUROPEAN METROPOLISES

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Abstract: The atmosphere is a dynamic layer surrounding Earth, with the troposphere directly influenced by human activities such as industry, agriculture, transportation, and urbanization. These anthropogenic processes introduce unnatural substances that can form dangerous pollutants, posing threats to human health and the environment. Urban areas experience higher temperatures, which accelerate chemical reactions, further worsening air quality. This study assesses air quality in five European cities—Bucharest, Vienna, Hamburg, Warsaw, and Barcelona—each having metropolitan areas with populations between 2.3 and 5.7 million. The objective is to identify primary pollution sources and evaluate air quality using the global pollution index method.

• Introduction

Atmospheric pollution negatively impacts both the environment and human health. Many European cities exceed air quality standards, exposing populations to major health risks. Greenhouse gases (like CO_2 , CH_4 , and N_2O) contribute to climate change, leading to phenomena like glacier melting, sea level rise, and extreme weather events.

Air pollutants such as tropospheric ozone, sulfur dioxide, and nitrogen oxides harm ecosystems, degrade structures, and pose direct health risks. Vulnerable populations include children, the elderly, and those with pre-existing health conditions. These risks necessitate efforts to monitor and mitigate air pollution, especially in densely populated urban areas.

• Material and method

The study examines air quality in Bucharest, Vienna, Hamburg, Warsaw, and Barcelona—urban centers with significant populations and industrial activities. Pollution sources include vehicles, industry, energy plants, and natural phenomena like volcanic activity and wildfires.

The monitoring of pollutants ($\text{PM}_{2.5}$, PM_{10} , CO , O_3 , NO_2 , SO_2) was conducted over 30 days (May 7–June 6) using real-time data from a global air quality platform. Air quality was evaluated using the global pollution index (I_{PG}), which compares observed pollutant levels to WHO standards. Pollution index scores, ranging from ideal (10) to severely impacted (1), were calculated to assess each city's air quality.

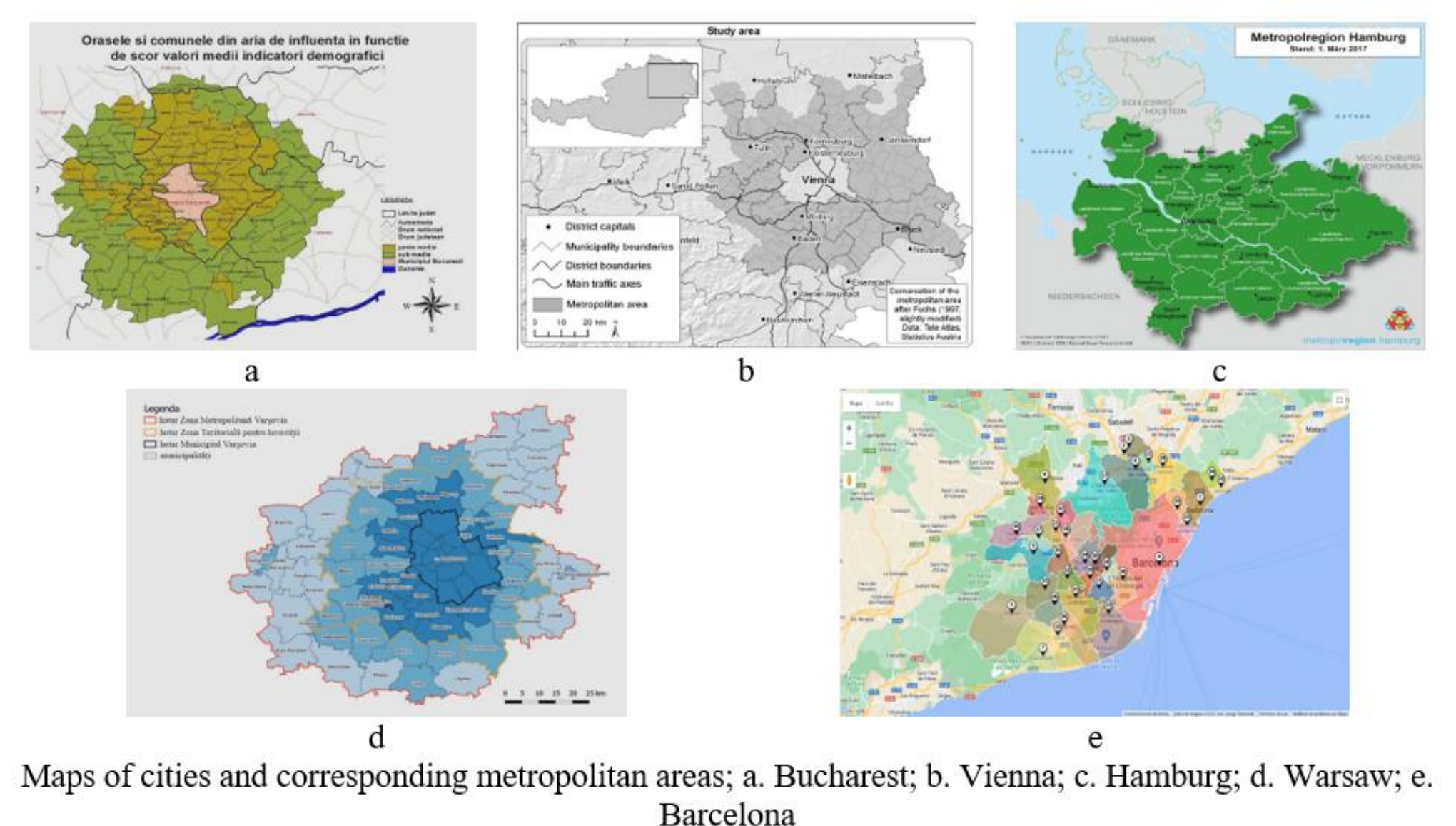
• Results and discussions

Data was collected on particulate matter, gases, and meteorological parameters across the five cities. The analysis revealed that Barcelona had the highest pollution index, likely due to high population density, while Vienna had the lowest.

Bucharest, Hamburg, and Warsaw showed moderate pollution levels.

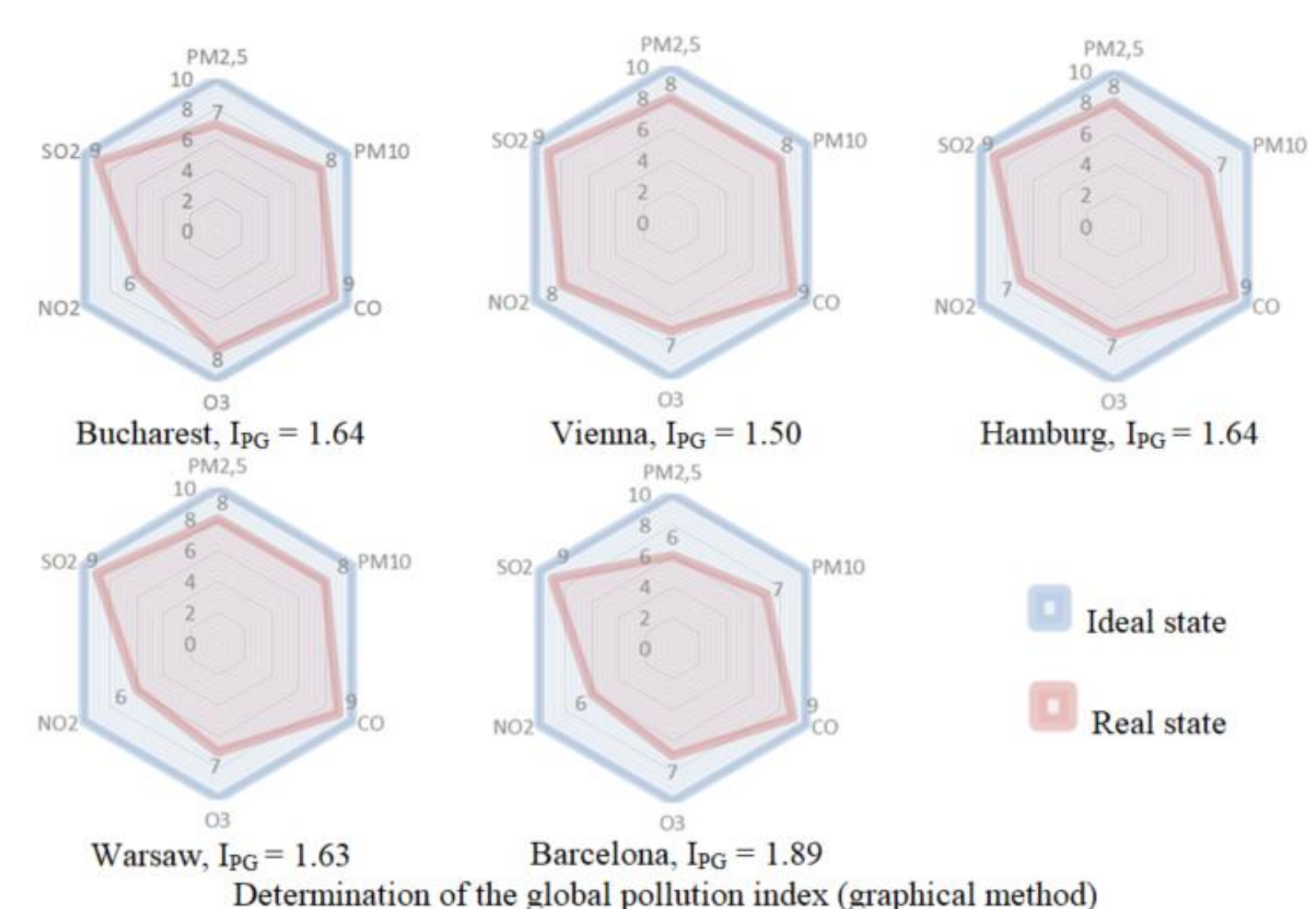
The global pollution index values suggest that, while pollution remains within acceptable limits, special measures may be needed in Barcelona to mitigate rising pollution risks.

These findings highlight the importance of implementing strategies like promoting public transport, energy conservation, and the use of green technologies to improve air quality.



Maps of cities and corresponding metropolitan areas: a. Bucharest; b. Vienna; c. Hamburg; d. Warsaw; e. Barcelona

The centralization of the calculated values								
City/AM		Parameters						I _{PG}
		PM _{2.5}	PM ₁₀	CO	O ₃	NO ₂	SO ₂	
		[μg/m ³]	[μg/m ³]	[μg/m ³]	[μg/m ³]	[μg/m ³]	[μg/m ³]	
Bucharest	V ₁	15	45	4000	100	25	40	1.64
	V _o	13	20	180	53	27	5	
	I _p	0.86	0.44	0.045	0.43	1.08	0.13	
	CS	7	8	9	8	6	9	
Vienna	V _o	4	12	200	72	12	2	1.50
	I _p	0.26	0.26	0.05	0.72	0.48	0.05	
	CS	8	8	9	7	8	9	
Hamburg	V _o	7	26	175	70	17	3.1	1.64
	I _p	0.46	0.57	0.044	0.7	0.68	0.08	
	CS	8	7	9	7	7	9	
Warsaw	V _o	7	19	550	60	42	3.3	1.63
	I _p	0.46	0.42	0.138	0.6	1.68	0.08	
	CS	8	8	9	7	6	9	
Barcelona	V _o	18	25	220	52	28	1.8	1.89
	I _p	1.2	0.55	0.055	0.52	1.12	0.05	
	CS	6	7	9	7	6	9	



• Conclusions

The study evaluated air quality over 30 days in five major European metropolitan areas. Key pollutants monitored included $\text{PM}_{2.5}$, PM_{10} , CO , O_3 , NO_2 , and SO_2 . Results indicate that while air pollution is generally under control, Barcelona is nearing thresholds that could impact living conditions. It is critical for governments and the European Union to enforce air quality regulations and make real-time data accessible through monitoring networks. Continuous efforts to prevent and reduce pollution are essential for protecting public health and the environment.