Romanian Journal of Ecology & Environmental Chemistry, 6(1), 2024

https://doi.org/10.21698/rjeec.2024.108

Short communication

Assessment of air quality in urban environments vulnerable to climate change effects

VALERIU DANCIULESCU, SIMONA MARIANA CALINESCU*, BOGDAN STANESCU, GHEORGHITA TANASE, CORNEL DAN, CRISTIAN CONSTANTIN, RUXANDRA MIRELA SOTIRNEL

National Research and Development Institute for Industrial Ecology – ECOIND, 57-73 Drumul Podul Dambovitei Street, district 6, 060652, Bucharest, Romania
**Corresponding author: simona.calinescu@incdecoind.ro*

Received: 24.06.2024 *Accepted: 02.07.2024* *Published: 04.07.2024*

Abstract
The atmosphere of urban localities is polluted by a number of pollutants emitted from industrial activities, car traffic and the activities of individual households. This study presents an assessment of the air pollution level in two cities (Galati and Tulcea), both of them being situated in eastern Romania. The correlation between air pollution and pollution sources and also between the causes that lead to high levels of air pollution in the studied cities were analyzed. Three air quality monitoring points were selected in the two cities, with the following pollutants: total suspended dust, PM10 dust, nitrogen dioxide, sulfur dioxide, and carbon monoxide. The pollution in the monitoring points was mainly influenced by the emissions from road traffic, the burning of methane gas for the production of heating agent, the industrial and agricultural activities performed in the monitoring area. Based on the result, it can be concluded that in the smaller city, Tulcea, the air pollution level was lower than in the Galat municipality, mainly due to the lower intensity of road traffic and polluting activities, but also the geographical positioning, close to the Danube Delta, a large area with green space, which presents a smaller pollution contribution. In areas characterized by lower population densities, specifically in small cities, there is a correlation between reduced population density and lower levels of atmospheric pollution.

Keywords: *dispersion of pollutants, emissions, air pollution, suspended particles*

INTRODUCTION

Air pollution is considered as the biggest environmental threat for human health. According to World Health Organization (WHO) the most important health effects of air pollution increase the morbidity and mortality caused by cardiovascular and respiratory diseases. Many new studies continue to document the adverse health effects generated by air pollution and also the fact that the air pollution is closely linked to the Earth's climate [1]. Regarding the European area, European Environment Agency (EEA) ranks air pollution as the most important environmental health risk factor in Europe (EU) [2].

Urban areas are additionally exposed to air polluting factors due to various economic activities and the increased density of residents generating household activities and greater road traffic. Severe air pollution is associated with the level of urbanization [3]

More than 70% of EU citizens live in urban areas and their exposure to high levels air pollution is severe.

Over the last three decades, the policies to reduce air pollution in Europe have been improved. The two main reference directions are the European standards and WHO global air quality guidelines.

The EU Ambient Air Quality Directive provides air quality standards for the protection of health and a selection of the air pollutants are regulated under the EU Directive, such as particulate matter, PM_{10}, $PM_{2,5,}$ nitrogen dioxide, ozone and benzo(a)pyrene, employed by the EEA to summarize the national air quality for each country [4]. Ambient Air Quality Directive was improved on 26 October 2022 as part of the European Green Deal. European Commission aligned the air quality standards more closely with the recommendation of the World Health Organization. The latest WHO Air Quality Guidelines with the revision on 22 September 2021 proposes for the particulate matter ($PM_{2,5}$) to be reduced by more than half. There exists a strong interrelationship between air pollution and climate change, as numerous chemicals that impair air quality are also significant contributors to greenhouse gas emissions. Drier and warmer weather conditions can lead to high air pollution levels, as they foster high photochemical production rates. Future heat waves may lead to an increase in the frequency and severity of wildfires, thereby amplifying emissions of harmful greenhouse gases and particulate matter (PM).

Considering the wide range of existing pollutants in the cities emitted by car traffic, industrial pollution [5, 6], including greenhouse gases [7], heavy metals in suspended powders [8, 9], with different sizes, polluting the air and the soil in cities and their toxicity [10, 11], it is important to make an assessment of the pollutants and the concentration levels for large urban agglomerations in Romania.

The primary sources of atmospheric pollution in cities are: road traffic and river traffic emissions; thermal agent produced by residential, commercial, and household activities; Industrial processes including thermal and electrical energy production; agricultural and agro-industrial activities.

Galati is a municipality with a population of around 270,000 people, located in the Siret Valley, crossed by the Danube River, in the eastern part of Romania. The city occupies an area of 246.4 km² and is situated at 45° 27' North latitude and 28° 02' East longitude. Galati's economy is centered around the shipyard, river port, steel works, and mineral port due to its location on the Danube River. Galati is under the influence of the eastern and less southern continental air masses, almost completely lacking the influence of the western air stopped by the Carpathian Mountains. The average annual temperature is 10°C. The average temperature during the summer is 21.3°C. During the winter, cold air masses come from the North and North East that produce temperature drops oscillating between 0 and -30°C.

Tulcea is a modernized city with an area of 115km² and a population of 65,600 inhabitants. It is an industrial city with a significant port for passenger and cargo ships, specializing in the transportation of raw materials. The city is also a major center for ship construction, repairs, and reed mining. The nearby airport, located on the Tulcea-Constanta road, km 15, serves the city. Tulcea is home to ALUM SA, the country's only producer of calcined alumina, as well as VARD Tulcea, an important shipyard. The city is also known as the "City of the Gates of the Danube Delta" and has developed a significant tourism industry. The climate of the municipality of Tulcea is temperate-continental with sub-Mediterranean influences. In winter, the arctic air is felt, from the North, which causes the temperature to drop. The average annual temperature in Tulcea is one of the highest in the country, being 10.8°C.

The aim of the study was to assess the air quality in two urban environments vulnerable to climate change effects. For a preliminary investigation, the air pollution contributors in Galati and Tulcea, including: total suspended dust, PM_{10} dust, nitrogen dioxide, sulfur dioxide, carbon monoxide was monitored.

The paper demonstrate the hypothesis that there is a correlation between reduced population density and lower levels of atmospheric pollution.

EXPERIMENTAL PART

Sampling points

In each Territorial Administrative Unit, three monitoring points were established to ensure representativeness for the tests performed. The equipment was installed to measure pollutant emissions and some meteorological parameters and to identify the conditions during the measurements.

The location of the sampling/measurement points and additional information regarding the weather conditions during the measurements are presented in figure 1 for Tulcea Municipality and in figure 2 for Galati Municipality.

The measurement period for Tulcea was between 23.10.2023 and 24.10.2023, the meteorological data for this period being: clear sky, moderate wind with a speed between 1.1÷1.7 m/s, E-NE direction, relative humidity 50÷58%, atmospheric pressure of 1008÷1012 mbar.
In Galati Municipality, the experimental study was carried out in 25.10.2023 and 26.10.2023. The meteorological data were: clear sky, moderate wind with a speed between 2.4÷3.9 m/s, S-SV direction, humidity 45÷74%, atmospheric pressure of 1004÷1008 mbar.

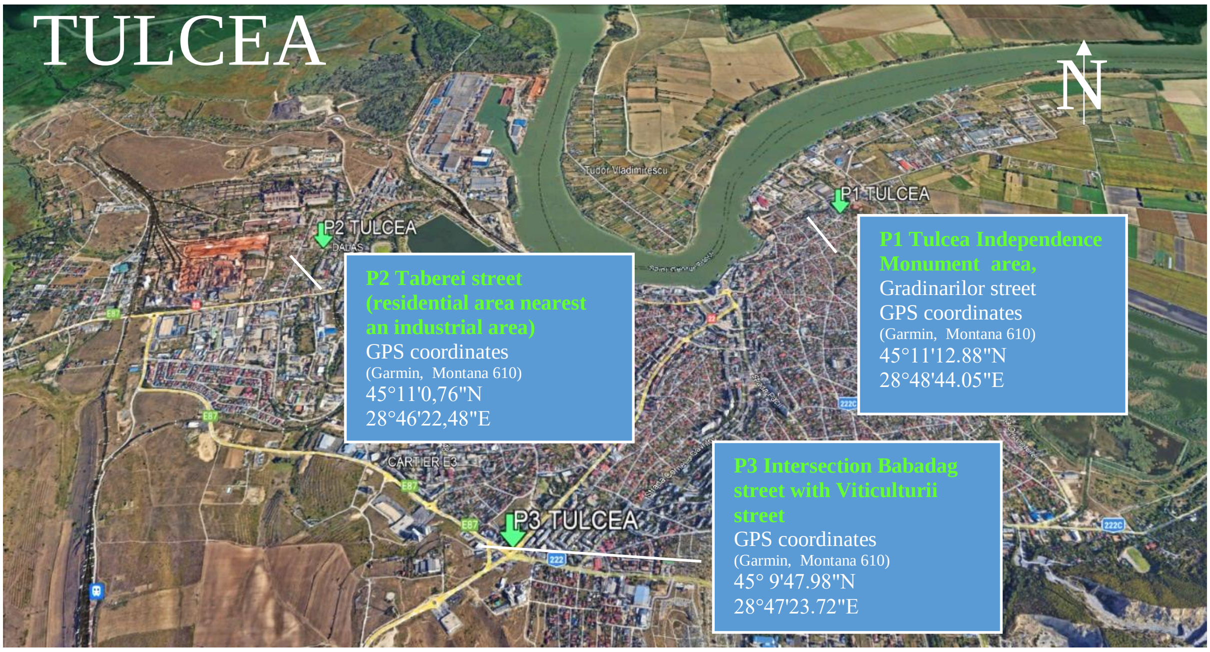

Fig. 1. Monitoring points in Tulcea Municipality *(source: Google Earth Pro, 2024, modified)*

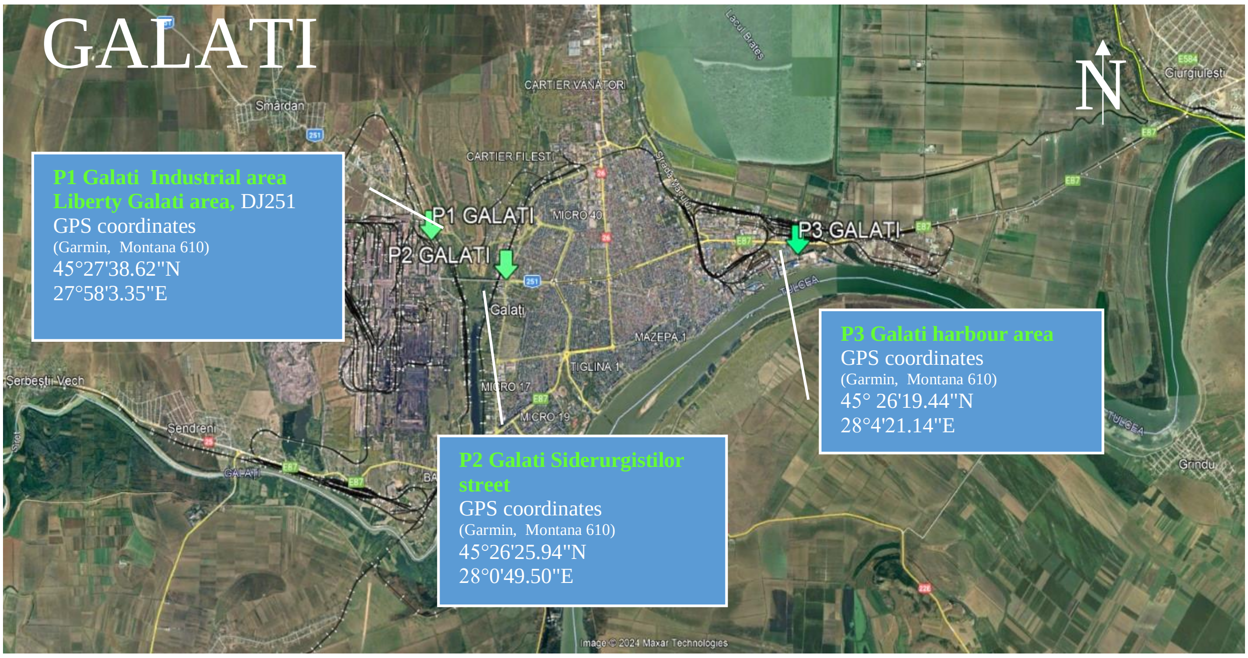

Fig. 2. Monitoring points in Galati Municipality *(source: Google Earth Pro, 2024, modified)*

Monitored parameters and equipment
TSP and PM_{10}
An important step in determining pollutant concentrations is sampling [12]. Thus, in the context of dust sampling, it involves collecting airborne particles by drawing a measured volume of air onto a filter at a predetermined flow rate using a dedicated sampling system. The system was equipped with impactors that facilitate the separation of size fractions, allowing the acquisition of high-quality data

for further analysis. The equipment used were Sven Leckel pumps with sampling probes for total dust and PM_{10} dust.
To determine the total suspended particles standard STAS 10813-76 [13] was applied. The standardized gravimetric measurement method was used for determination of PM_{10} mass fraction on suspended particles [14].

Carbon monoxide
The determination of carbon monoxide in the surrounding air was carried out with HORIBA APMA-370 automatic analyzer, which comply with the standard SR EN 14626:2012 [15]. The APMA-370 is a device for continuously monitoring CO concentrations using a Non-dispersion cross modulation infrared analysis method.

Sulfur dioxide
The determination of sulfur dioxide in the surrounding air was carried out with HORIBA APSA-370 automatic analyzer, according to standards SR EN 14212:2012 and SR EN 14212:2012/AC:2014 [16]. The APSA-370 is a device for the continuous monitoring of atmospheric SO_2 using UV fluorescence

Nitrogen dioxide
The determination of nitrogen dioxide in the surrounding air was carried out with HORIBA APNA-370, which comply with the standard SR EN 14211:2012 [17] for nitrogen dioxide. The APNA-370 continuously monitors atmospheric NO, NO_2 and NO_x concentrations using a cross-flow modulated semi decompression chemiluminescence method.

The measured meteorological parameters were: temperature, humidity, atmospheric pressure, wind speed and direction. It can be mentioned that the points chosen for monitoring were established taking into account several factors and it was ensured that the level of pollution will not be influenced by a single source of pollution, precisely to ensure the relevance of the determinations made, providing a comprehensive representation of the quality local air.

RESULTS AND DISCUSSION

Regarding the impact of pollutants on human health and ecosystems [18], Directive 2008/50/EC transposed in Romania by Law no. 104/2011 [19], identifies as important indicators, suspended particles PM_{10}, nitrogen dioxide, sulfur dioxide, carbon monoxide. Concerning suspended dust, in Romanian standard STAS 12574-87 is established the maximum allowable concentration (MAC) [20]. In table 1 are presented the allowed limits for the concentration of pollutants in the air.

Table 1. Allowed limit values for the pollutants concentration in the surrounding air (emissions)

Pollutant	Period	UM	Allowed limit values according to	
			[19]	[20]
Total Suspended Particles (TSP)	30 min	mg/m^3	-	0.5
Suspended particles	daily	mg/m^3	-	0.15
PM_{10}	24 hours	$\mu g/m^3$	50	-
CO	8 hours	$\mu g/m^3$	10000	-
NO_2	1 hour	$\mu g/m^3$	200	-
SO_2	1 hour	$\mu g/m^3$	350	-

The obtained results from Tulcea monitoring period are presented in Table 2.
The experimental data indicate that P1 and P3 registered the highest levels of carbon monoxide and sulfur dioxide, which is consistent with the more intense vehicular traffic, proximal to the sampling locations. In contrast, P2 shows negligible contribution from road traffic, whereas industrial activities exert a substantial influence on the levels of carbon monoxide, nitrogen dioxide and sulfur dioxide.

The emission of these pollutants as byproducts of fossil fuel combustion, resulting from technological processes involved in product manufacturing and combustion facilities, can be identified as potential sources of pollution. The obtained results for all investigated parameters were situated below the allowed limit values according to the in force legislation [19, 20].

Table 2. Pollutants concentration (average values) for emissions in Tulcea Municipality

Sampling point	Pollutant	M.U.	Concentration	Monitoring period
P1 situated near Independence Monument area	PM_{10}	µg/m^3	38.0	24 ore
	CO	µg/m^3	435	8 ore
	NO_2	µg/m^3	77.5	1 ora
	SO_2	µg/m^3	65.9	1 ora
P2 situated on Taberei Street	TSP	mg/m^3	0.09	30 min
	PM_{10}	µg/m^3	32.0	24 hours
	CO	µg/m^3	211	8 hours
	NO_2	µg/m^3	137	1 hour
	SO_2	µg/m^3	162	1 hour
P3 situated on intersection of Babadag Street with Viticultorilor Street	TSP	mg/m^3	0.11	30 min
	PM_{10}	µg/m^3	43.0	24 hours
	CO	µg/m^3	354	8 hours
	NO_2	µg/m^3	83.1	1 hour
	SO_2	µg/m^3	171	1 hour

The concentration values of pollutants determined in the samples collected from Galati Municipality are presented in Table 3.

Table 3. Pollutants concentration (average values) for emissions in Galati Municipality

Sampling point	Pollutant	M.U.	Concentration	Monitoring period
P1 situated near DJ251, proximity Liberty Galati	PM_{10}	µg/m^3	49.0	24 hours
	CO	µg/m^3	221	8 hours
	NO_2	µg/m^3	25.9	1 hour
	SO_2	µg/m^3	198	1 hour
P2 situated on Siderurgistilor Boulevard	TSP	mg/m^3	0.08	30 min
	PM_{10}	µg/m^3	37.0	24 hours
	CO	µg/m^3	272	8 hours
	NO_2	µg/m^3	41.3	1 hour
	SO_2	µg/m^3	169	1 hour
P3 situated on Port Galati area	TSP	mg/m^3	0.14	30 min
	PM_{10}	µg/m^3	33.0	24 hours
	CO	µg/m^3	305	8 hours
	NO_2	µg/m^3	24.7	1 hour
	SO_2	µg/m^3	144	1 hour

The experimental data shows that P1 exhibits the highest concentrations of pollutants. The elevated levels of sulfur dioxide and PM_{10} dust are attributed to the intense road traffic, especially the presence of large vehicles that traverse the area, situated on the city's outskirts.
However, the TSP concentration recorded at P1 was much higher compared at P2 and P3. The high TSP levels can be attributed to the resuspension and entrainment of local dust particles, including those from neighboring agricultural lands, which are lifted into the air by wind currents and turbulent flows generated by the large vehicles. Furthermore, it can be inferred that particles larger than PM_{10} by weight comprise a significant proportion of the TSP, with these larger particles primarily resulting from local resuspension mechanisms driven by wind and currents associated with the transit of large vehicles in the area.
Same situation than in Tulcea was reported, the obtained results for all investigated parameters were situated below the allowed limit values according to the in force legislation [19, 20].

CONCLUSIONS

Analyzing the monitoring results (TSP, PM_{10}, carbon monoxide, sulfur dioxide and nitrogen dioxide) in all investigated points from both locations, the values of the were situated below the limits imposed by the national legislation. Comparing the concentrations obtained in the monitoring points from Tulcea to those obtained in Galati, it was observed that Tulcea had lower concentrations due to less intense economic activities and road traffic, as well as a more favorable urban layout.
To maintain or reduce pollutant concentrations in the surrounding air various reduction measures can be implemented: decreasing industrial emissions; decreasing motor vehicle emissions (lowering emission standards for motor vehicles, increasing the number of zero emissions vehicles, electric or hybrid); reducing road traffic through efficient traffic management and parking spaces optimization; increasing public transportation use and promoting non-polluting transportation methods (bicycles, electric scooters, walking, etc.); increasing green areas in cities.

ACKNOWLEDGEMENTS

This work was carried out through the “Nucleu” Program within the National Research Development and Innovation Plan 2022-2027 with the support of Romanian Ministry of Research, Innovation and Digitalization, contract no. 3N/2022, Project code PN 23 22 02 02.

REFERENCES

[1] WORLD HEALTH ORGANIZATION. Available from: Air pollution (who.int) [19.06.2024]
[2] EUROPEAN ENVIRONMENT AGENCY. Available from: Air pollution | European Environment Agency's home page (europa.eu) [19.06.2024]
[3] BANZHAF, E., BARRERA, F., KINDLER, A., REYES-PAECKE, S., SCHLINK, U., WELZ, J., KABISCH, S., Ecol. Ind., **45**, 2014, p. 664.
[4] CHIARINI, B., D’AGOSTINO, A., MARZANO, E., REGOLI, A., Ecol. Ind., **121**, 2021, p 1, https://doi.org/10.1016/j.ecolind.2020.107144.
[5] POPA, O., CONSTANTIN, C., CALINESCU, S., TANASE G., STANCU, V., NOVAC, L., Rom. J. Ecol. Environ. Chem., **5**, no. 2, 2023, p. 97, https://doi.org/10.21698/rjeec.2023.210.
[6] BRATU, M., BUCUR, E., DANCIULESCU, V., PETRESCU, M., TANASE, G., VASILE**,** O., Rom. J. Ecol. Environ. Chem., **2**, no. 2, 2020, p. 130, https://doi.org/10.21698/rjeec.2020.216.
[7] DANCIULESCU, V., VASILE, A., PASCU, L.F., STANESCU, B.A., NICOLESCU, I., Rev. Chim., **68,** no.8, 2017, p. 1700.
[8] DANCIULESCU, V., BUCUR, E., PASCU, L.F., VASILE, A., BRATU, M., J. Environ. Prot. Ecol., **16**, no. 3, 2015, p. 815.
[9] PASCU, L.F., DANCIULESCU, V., CALINESCU, S., VASILE I.I., NICOLESCU I., BANCIU, A.R., NITA-LAZAR, M., VASILE, G.G., *Atmosphere*, ***15****, no.* 1, 2024, p.1, https://doi.org/10.3390/atmos15010141.
[10] STANESCU, B.A., CUCIUREANU, A., NICOLESCU, I.C., GASNAC, M., CERNICA, G., Rom. J. Ecol. Environ. Chem., **4**, no. 2, 2022, p. 149, https://doi.org/10.21698/rjeec.2022.215.
[11] DANCIULESCU, V., COZEA, A., BUCUR, E., TANASE, G., BRATU, M., Rom. J. Ecol. Environ. Chem. 2022, **4**, no. 1, p. 68, https://doi.org/10.21698/rjeec.2022.107.
[12] US EPA Quality Assurance Handbook for Air Pollution Measurement Systems Ambient Air specific Methods, vol. II. US Environmental Protection Agency, US Government Printing Office, Washington, DC (1994) Section 2,11; EPA/600/R-94/038a; https://nepis.epa.gov [07.02.2022].
[13] STAS 10813-76 - Air purity. Determination of suspended dust, in Romanian.
[14] SR EN 12341:2014 - Air quality. The standardized gravimetric measurement method for determining the mass fraction of PM_{10} or $PM_{2.5}$ of suspended particles.
[15] SR EN 14626:2012 - Ambient air. Standardized method for measuring carbon monoxide concentration by non-dispersive infrared spectroscopy.
[16] SR EN 14212:2012, SR EN 14212:2012/AC:2014 - Ambient air. Standardized method for measuring sulfur dioxide concentration by ultraviolet fluorescence.

[17] SR EN 14211:2012 - Ambient air. Standardized method for measuring the concentration of nitrogen dioxide and nitrogen monoxide by chemiluminescence.
[18] GALON-NEGRU, A.G., OLARIU, R.I., ARSENE, C., Sci. Total Environ., **695**, 2019, https://doi.org/10.1016/j.scitotenv.2019.133839.
[19] Directive 2008/50/CE transpose in Romanian Legislation by Law no.104/2011 regarding air quality, in Romanian.
[20] STAS 12574 – 87. Air in protected areas. Quality conditions, in Romanian.

Citation: Danciulescu, V., Calinescu, M.S., Stanescu, B., Tanase, G., Dan, C., Constantin, C., Sotirnel, R.M., Assessment of air quality in urban environments vulnerable to climate change effects, *Rom. J. Ecol. Environ. Chem.*, **2024**, 6, no.1, pp. 87÷93.