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COMPARATIVE ANALYSIS OF MEAN MONTHLY AND ANNUAL CONCENTRATIONS OF PARTICULATE MATTER PM2.5 AND PM10 IN TBILISI, BATUMI, KUTAISI AND RUSTAVI IN 2019-2022

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Abstract: *Results of the comparative analysis of the mean monthly and annual concentrations of particulate matter PM2.5 and PM10 at four locations of Georgia (Tbilisi , Batumi, Kutaisi and Rustavi) in 2019-2022 are presented. An analysis of the correlations between the indicated characteristics of air pollution has been carried out. The variability of the average annual values of PM2.5 and PM10 in the study period of observations was studied. In particular, it was found that in Tbilisi in 2020-2021, compared to 2019, there was a significant decrease in the average annual concentration of aerosols due to restrictions on vehicle movement related to the Covid-19 pandemic. This tendency has continued in the post-Covid-19 period in 2022. It is noted that for the entire observation period, the average annual concentration of PM2.5 and PM10 was above the permissible norm for all investigation locations.*

Key words: *Atmospheric aerosols, particulate matter, PM2.5, PM10.*

Introduction

Over the past four decades in the Department of Atmospheric Physics at the M. Nodia Institute of Geophysics, TSU, various works were carried out on the study of atmospheric aerosols [1,2].

The results of studies of the long-term dynamics of surface air pollution in Tbilisi (weight concentration of aerosols, nitrogen oxides, sulfur dioxide, ozone) are presented in [3,4]. Some preliminary results of the complex monitoring of Surface Ozone Concentration (SOC), intensity of summary solar radiation and sub-micron aerosols content in air in Tbilisi in 2009-2010 in [5] are presented.

In [6], the results of a study of variations in the concentration of submicron aerosols with a diameter of ≥0.1 μm and their relationship with the content of radon (Rn) in the surface air layer of the city of Tbilisi are presented. Considerable attention was paid to studies of the relationship between aerosol pollution of the atmosphere, including radioactive pollution, and thunderstorm and hail processes, as well as the precipitation regime [7]. A comparative analysis of aerosol air pollution in Tbilisi and Kutaisi was carried out [8]. The possibility of using the METEOR 735CDP10 meteorological radar for monitoring the movement of dust formations in the atmosphere was considered [9].

Several studies have examined the effects of traffic restrictions in Tbilisi due to the Covid-19 pandemic on airborne air pollution levels [10-12] compared to the pre-pandemic period [13]. In general, it was found that the level of aerosol air pollution in the absence of vehicular traffic decreased significantly. Statistical characteristics of monthly mean and annual concentrations of particulate matter PM2.5 and PM10 in three points of Tbilisi in 2017-2022 in [14] are presented.

This work is a continuation of previous studies [8-14]. Below are the results of the statistical analysis of the average monthly and annual concentrations of particulate matter PM2.5 and PM10 at four locations of Georgia - Tbilisi, Batumi, Kutaisi and Rustavi in 2019-2022.

Study area, material and methods

Study area – four locations of Georgia (Tbilisi – Tb., Batumi – Bat., Kutaisi – Kut. and Rustavi – Rust.). The data of Georgian National Environmental Agency about the daily mean values of dust concentration (atmospheric particulate matter - PM2.5 and PM10) [http://air.gov.ge/reports_page] that averaged on four indicated stations are used. Note that the data for Tbilisi are averaged over three observation points [14]. Period of observation: January 2019 - December 2022.

In the proposed work the analysis of data is carried out with the use of the standard statistical analysis methods [15,16]. Missed data of time-series of observations were restored in the correspondence with the standard methods [15].

The following designations will be used below: Min – minimal values; Max - maximal values; St Dev - standard deviation; Cv = 100·St Dev/Average, coefficient of variation (%); R coefficient of linear correlation. Tb_PM2.5, Tb_PM10 …etc. - concentrations of particulate matter PM2.5 and PM10 in Tbilisi … etc. The difference between the mean values of PM with the use of Student's criterion was determined (level of significance α is not worse than 0.15).

In the correspondence with the standards of the World Health Organization maximum permissible concentration (MPC) composes: annual mean for PM2.5 - 10 μg/m³ and for PM10 - 20 μg/m³ [17]. In the text below, the dimension of aerosol concentration (μg/m³) is mostly omitted.

Results and discussion

Results in Fig. 1,3 and Table 1,2 are presented. In Fig. 1 time-series of mean monthly values of PM2.5 and PM10 in Tbilisi, Batumi, Kutaisi and Rustavi in 2019-2022 are presented. Table 1 presents the statistical characteristics of the data shown in Fig. 1.

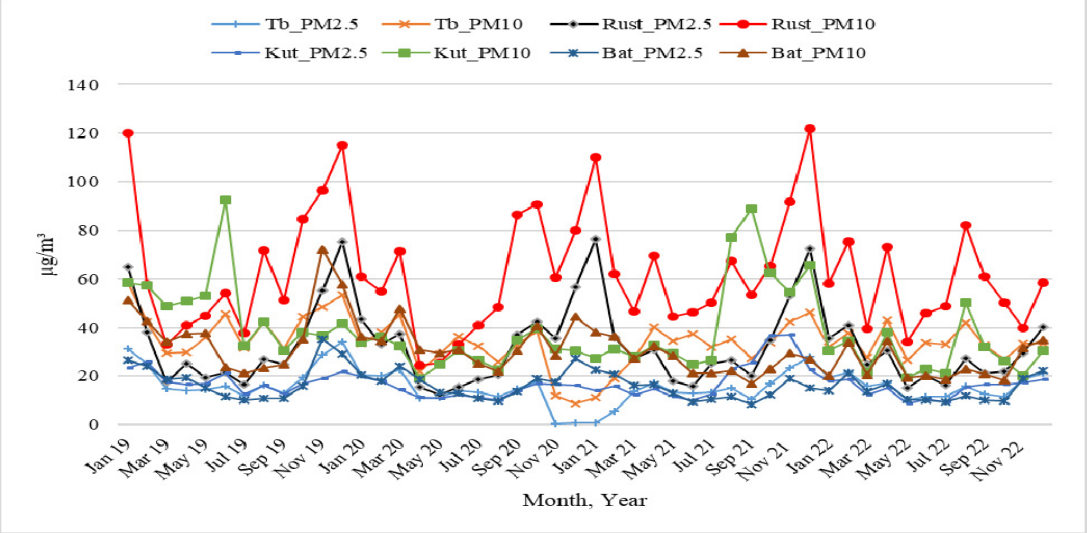


Fig. 1. Time series of mean monthly values of PM2.5 and PM10 in Tbilisi, Batumi, Kutaisi and Rustavi in 2019-2022.

In particular, as follows from Fig. 1 and Table 1 the range of variability in 2019-2022 for PM2.5 values is from 0.5 (Tbilisi) to 76.3 (Rustavi), and PM10 - from 8.6 (Tbilisi) to 121.7 (Rustavi). The range of variability of the average values of PM2.5 for the specified period of time is from 15.7 (Tbilisi) to 32.3 (Rustavi), and PM10 - from 30.8 (Batumi) to 62.1 (Rustavi). Thus, the highest level of air pollution with solid particles PM2.5 and PM10 is observed in Rustavi. The lowest level of air pollution with particulate matter PM2.5 is observed in Tbilisi, and PM10 in Batumi.

Table 1. Statistical characteristics of mean monthly values of PM2.5 and PM10 in Tbilisi, Batumi, Kutaisi and Rustavi in 2019-2022.

Variable	Tb_ PM2.5	Tb_ PM10	Rust_ PM2.5	Rust_ PM10	Kut_ PM2.5	Kut_ PM10	Bat_ PM2.5	Bat_ PM10
Max	34.1	58.6	76.3	121.7	36.9	92.6	35.2	72.0
Min	0.5	8.6	12.4	24.3	8.6	19.2	8.3	17.0
Mean	15.7	34.0	32.3	62.1	16.7	38.4	16.2	30.8
St Dev	6.9	9.9	16.3	24.2	6.0	17.2	6.0	11.0
Cv,%	44.2	29.0	50.4	38.9	35.6	44.7	37.3	35.6
	Correlation Matrix							
Tb_PM2.5	1	0.89	0.42	0.46	0.46	0.29	0.42	0.48
Tb_PM10	0.89	1	0.23	0.42	0.34	0.38	0.18	0.34
Rust_PM2.5	0.42	0.23	1	0.90	0.47	0.18	0.71	0.63
Rust_PM10	0.46	0.42	0.90	1	0.45	0.31	0.52	0.52
Kut_PM2.5	0.46	0.34	0.47	0.45	1	0.70	0.28	0.21
Kut_PM10	0.29	0.38	0.18	0.31	0.70	1	-0.01	0.04
Bat_PM2.5	0.42	0.18	0.71	0.52	0.28	-0.01	1	0.93
Bat_PM10	0.48	0.34	0.63	0.52	0.21	0.04	0.93	1

In general (Table 1), the linear correlation coefficient for all studied parameters varies from -0.01 (negligible correlation, pair Bat_PM2.5 - Kut_PM10) to 0.93 (very high correlation, pair Bat_PM2.5 - Bat_PM10). The R value for PM2.5 varies from 0.28 (negligible correlation, pair Bat_PM2.5 - Kut_PM2.5) to 0.71 (high correlation, pair Bat_PM2.5 - Rust_PM2.5). The R value for PM10 varies from 0.04 (negligible correlation, pair Bat_PM10 - Kut_PM10) to 0.52 (moderate correlation, pair Bat_PM10 - Rust_PM10).

In Table 2 Max and Min mean monthly values of PM2.5 and PM10 in Tbilisi, Batumi, Kutaisi and Rustavi from 2019 to 2022 are presented.

Table 2. Max and Min mean monthly values of PM2.5 and PM10 in Tbilisi, Batumi, Kutaisi and Rustavi in 2019-2022.

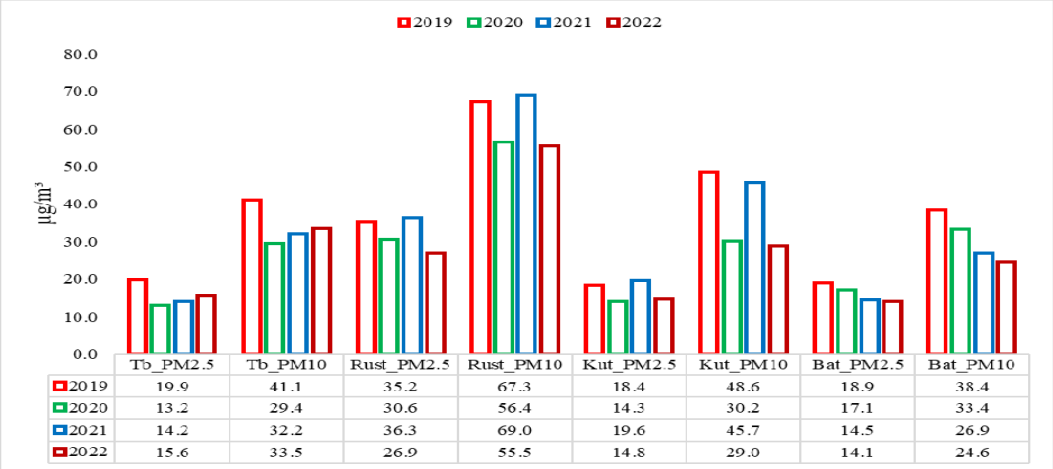
Variable	Tb_ PM2.5	Tb_ PM10	Rust_ PM2.5	Rust_ PM10	Kut_ PM2.5	Kut_ PM10	Bat_ PM2.5	Bat_ PM10
Year	2019							
Max	34.1	58.6	75.2	120.0	26.0	92.6	35.2	72.0
Min	11.9	29.4	16.7	32.9	12.5	30.7	10.0	21.3
Year	2020							
Max	22.7	45.1	56.8	90.6	19.8	39.4	27.3	47.7
Min	0.5	8.6	12.4	24.3	10.0	19.2	9.6	22.1
Year	2021							
Max	27.9	46.2	76.3	121.7	36.9	89.0	22.5	37.9
Min	0.8	11.3	15.7	44.5	10.0	24.9	8.3	17.0
Year	2022							
Max	21.7	43.1	40.8	82.2	18.7	50.3	22.3	34.7
Min	10.2	26.5	15.0	33.9	8.6	19.6	9.3	18.3

In different years, air pollution in the cities under study varies within the following limits (Table 2).

PM2.5: 2019 - from 10 (Batumi) to 75.2 (Rustavi); 2020 - from 0.5 (Tbilisi) to 56.8 (Rustavi); 2021 - from 0.8 (Tbilisi) to 76.3 (Rustavi); 2022 - from 8.6 (Kutaisi) to 40.8 (Rustavi).

PM10: 2019 - 21.3 from (Batumi) to 120 (Rustavi); 2020 - from 8.6 (Tbilisi) to 90.6 (Rustavi); 2021 - from 11.3 (Tbilisi) to 121.7 (Rustavi); 2022 - from 18.3 (Batumi) to 82.2 (Rustavi).

Fig. 2 presented mean annual values of PM2.5 and PM10 in Tbilisi, Batumi, Kutaisi and Rustavi from 2019 to 2022.



	Tb_PM2.5	Tb_PM10	Rust_PM2.5	Rust_PM10	Kut_PM2.5	Kut_PM10	Bat_PM2.5	Bat_PM10
2019	19.9	41.1	35.2	67.3	18.4	48.6	18.9	38.4
2020	13.2	29.4	30.6	56.4	14.3	30.2	17.1	33.4
2021	14.2	32.2	36.3	69.0	19.6	45.7	14.5	26.9
2022	15.6	33.5	26.9	55.5	14.8	29.0	14.1	24.6

Fig. 2. Mean annual values of PM2.5 and PM10 in Tbilisi, Batumi, Kutaisi and Rustavi in 2019-2022.

Compared to 2019 (Pre-Covid-19 period), in subsequent years, significant changes in the average annual concentration of particulate matter in the air were observed in the following cities (Fig. 2).

- 2020 (Covid-19 period): Tbilisi and Kutaisi, decrease in concentrations of PM2.5 and PM10.
- 2021(Covid-19 period): Tbilisi and Batumi, decrease in concentrations of PM2.5 and PM10.
- 2022 (Post-Covid-19 period): Tbilisi, decreased concentrations of PM2.5 and PM10. Kutaisi and Batumi - decrease in PM10 concentration.

Note that Covid-19 restrictions on the movement of transport had the greatest effect on reducing the level of air pollution in Tbilisi (2020 and 2021), in Kutaisi this effect was observed in 2020, in Batumi - in 2021. In Rustavi, this effect was not observed.

Conclusion

In the future, as new data accumulates, it is planned to continue similar studies of the variability of daily, average monthly and average annual values of PM2.5 and PM10 in various regions of Georgia.

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