

STATISTICAL CHARACTERISTICS OF MEAN MONTHLY AND ANNUAL CONCENTRATIONS OF PARTICULATE MATTER PM_{2.5} AND PM₁₀ IN TBILISI IN 2017-2023

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Abstract: Results of the statistical analysis of the average monthly and annual concentrations of particulate matter PM_{2.5} and PM₁₀ at three locations in Tbilisi (Kazbegi av., Tsereteli av. and Varketili) in 2017-2023 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 PM_{2.5} and PM₁₀ in the study period of observations was studied. In particular, it was found that after a significant decrease in the average annual concentration of aerosols in 2020-2021 due to restrictions on vehicle movement related to the COVID-19 pandemic, an increase in aerosol pollution of the atmosphere has been observed in recent years. Thus, in 2023, the monitoring station on Tsereteli Avenue fixed a record increase in PM₁₀ content in the air. In general, over the entire observation period, the average annual concentration of PM_{2.5} and PM₁₀ was above the permissible limit.

Key words: Atmospheric aerosols, particulate matter, PM_{2.5}, PM₁₀.

Introduction

Over the past four decades, the Department of Atmospheric Physics of the M. Nodia Institute of Geophysics, TSU has been conducting various studies on atmospheric aerosols [1-12].

In particular, a comparative analysis of aerosol air pollution with PM_{2.5} and PM₁₀ particles in four Georgian settlements – Tbilisi, Batumi, Kutaisi and Rustavi – was conducted in [5,6].

A number of studies examined the impact of traffic restrictions in Tbilisi due to the COVID-19 pandemic on the level of air pollution in the air compared to the pre-pandemic period [7-10]. Particular attention was paid to studies of the dynamics of aerosol air pollution in Tbilisi, the results of which were constantly updated as new data became available [11,12].

This work is a continuation of previous studies. Below are the results of a statistical analysis of the average monthly and annual concentrations of PM_{2.5} and PM₁₀ particles in Tbilisi in 2017-2023.

Study area, material and methods

Study area – three locations of Tbilisi (A. Kazbegi av. – KZBG, A. Tsereteli av. – TSRT, Varketili – VRKT). Coordinates of these locations of air pollution measurements points in [11] is presented.

The data of Georgian National Environmental Agency about the daily mean values of dust concentration (atmospheric particulate matter – PM_{2.5} and PM₁₀) [http://air.gov.ge/reports_page] that averaged on three indicated stations are used. Period of observation: January 2017 – December 2023.

In the proposed work the analysis of data is carried out with the use of the standard statistical analysis methods [13]. Missed data of time-series of observations were restored in the correspondence with the standard methods.

The following designations will be used below: Min – minimal values; Max – maximal values; St Dev – standard deviation; $C_v = 100 \cdot \text{St Dev} / \text{Average}$, coefficient of variation (%); R coefficient of linear correlation.

KZBG(PM2.5), KZBG(PM10) ...etc. – concentrations of particulate matter PM2.5 and PM10 on the Kazbegi av. measurement point, etc.; Av(PM2.5) and Av(PM10) – averaged over all three stations PM2.5 and PM10.

In the correspondence with the standards of the World Health Organization maximum permissible concentration (MPC) composes: annual mean for PM2.5 – 10 mcg/m³ and for PM10 – 20 mcg/m³ [14]. In the text below, the dimension of aerosol concentration (mcg/m³) is mostly omitted.

Results and discussion

Results in Fig. 1,2 and Table 1 are presented.

In Fig. 1 and 2 time-series of mean monthly and annual values of PM2.5 and PM10 at three points in Tbilisi and their averaged values for all measurement points in 2017-2023 are presented. Table 1 provides statistical characteristics of the data shown in Fig. 1.

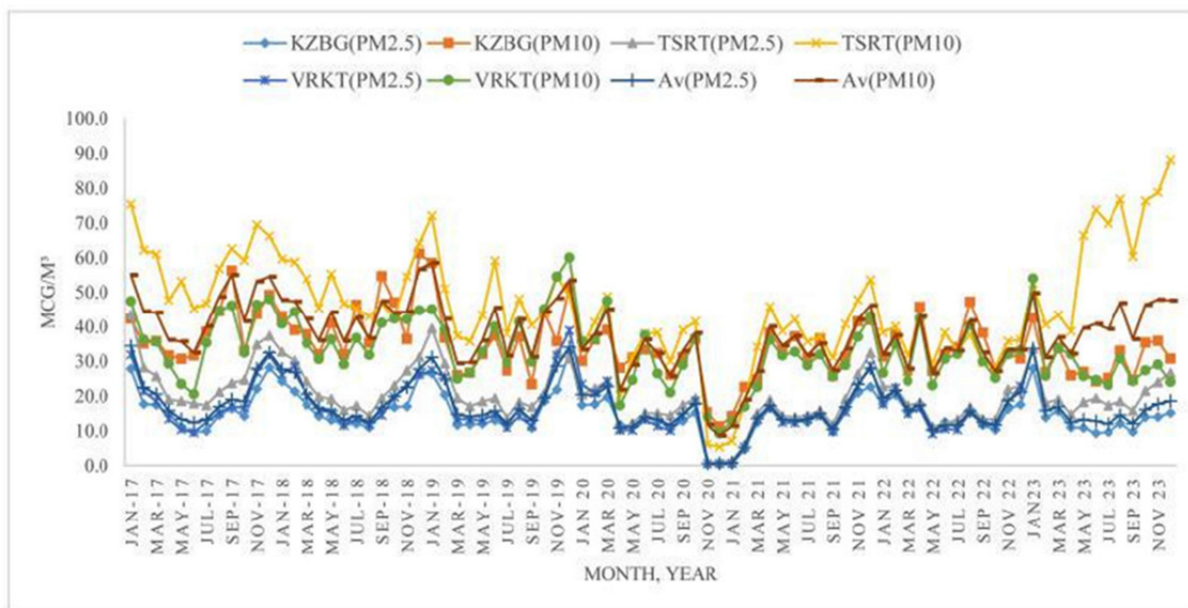


Fig. 1. Time-series of mean monthly values of PM2.5 and PM10 at three points in Tbilisi and their averaged values for all measurement points in 2017-2023.

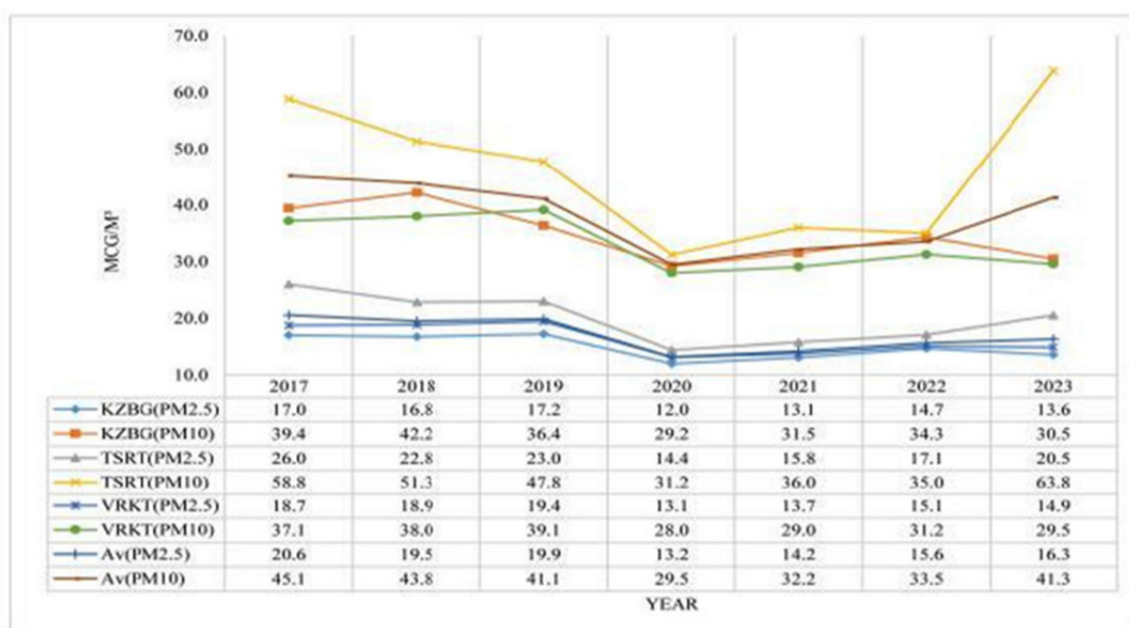


Fig. 2. Time series of mean annual values of PM2.5 and PM10 at three points in Tbilisi and their averaged values for all measurement points in 2017-2023.

In particular, as follows from Fig. 1 and Table 1, in 2017-2023 the range of variability for PM2.5 values is from 0.3 (KZBG) to 43.6 (TSRT), and PM10 – from 5.4 (TSRT) to 88.1 (TSRT). The range of variability of the average values of PM2.5 for the specified period of time is from 0.5 to 34.4, and PM10 – from 8.6 to 58.6. The highest level of air pollution with solid particles PM2.5 and PM10 is observed in TSRT (19.9 and 46.3 accordingly). The lowest level of air pollution with particulate matter PM2.5 is observed in KZBG (14.9), and PM10 in VRKT (33.1).

In general (Table 1), the linear correlation coefficient for all studied parameters varies from 0.47 (low correlation, pair VRKT(PM2.5) – TSRT(PM10)) to 0.98 (very high correlation, pair Av(PM2.5) – KZBG(PM2.5)).

Table 1. Statistical characteristics of mean monthly values of PM2.5 and PM10 in Tbilisi in 2017-2023.

Variable	KZBG (PM2.5)	KZBG (PM10)	TSRT (PM2.5)	TSRT (PM10)	VRKT (PM2.5)	VRKT (PM10)	Av (PM2.5)	Av (PM10)
Max	32.7	61.2	43.6	88.1	39.3	60.1	34.4	58.6
Min	0.3	11.3	0.8	5.4	0.5	9.3	0.5	8.6
Average	14.9	34.8	19.9	46.3	16.3	33.1	17.0	38.1
St Dev	5.8	9.1	7.9	16.1	7.5	9.6	6.9	9.8
C _v , %	38.9	26.2	39.4	34.7	46.2	29.0	40.4	25.8
Correlation Matrix								
KZBG(PM2.5)	1	0.76	0.91	0.52	0.96	0.85	0.98	0.80
KZBG(PM10)	0.76	1	0.68	0.49	0.67	0.83	0.72	0.85
TSRT(PM2.5)	0.91	0.68	1	0.73	0.90	0.77	0.97	0.86
TSRT(PM10)	0.52	0.49	0.73	1	0.47	0.48	0.60	0.85
VRKT(PM2.5)	0.96	0.67	0.90	0.47	1	0.86	0.98	0.74
VRKT(PM10)	0.85	0.83	0.77	0.48	0.86	1	0.85	0.84
Av(PM2.5)	0.98	0.72	0.97	0.60	0.98	0.85	1	0.82
Av(PM10)	0.80	0.85	0.86	0.85	0.74	0.84	0.82	1

The R value for PM2.5 varies from 0.90 (high correlation, pair VRKT(PM2.5) – TSRT (PM2.5)) to 0.98 (very high correlation, pair Av(PM2.5) – KZBG(PM2.5)).

The R value for PM10 varies from 0.48 (low correlation, pair VRKT(PM10) – TSRT(PM10)) to 0.85 (high correlation, pair Av(PM10) – KZBG(PM2.5) and pair Av(PM10) – TSRT(PM10)).

The R value between PM2.5 and PM10 varied from 0.73 (high correlation, TSRT) to 0.86 (high correlation, VRKT). Between Av(PM2.5) and Av(PM10) the R value is 0.79 (high correlation).

It is important to note that in 2023, the monitoring station on Tsereteli Avenue (TSRT) fixed a record increase in PM10 content in the air (88.1 on monthly data and 63.8 on annual data, Fig. 1,2 and Table 1). Apparently, this was connected with large-scale construction work to rehabilitate Tsereteli Avenue.

In conclusion, we note that in general, over the entire observation period, the average annual concentration of PM2.5 and PM10 was above the permissible limit.

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 Tbilisi and another regions of Georgia.

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