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DATA ANALYSIS ON MEAN MONTHLY AND ANNUAL CONCENTRATIONS OF PARTICULATE MATTER PM2.5 AND PM10 IN TBILISI IN 2017-2024

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Abstract. *The article presents the results of statistical analysis of mean monthly and annual concentrations of particulate matter PM2.5 and PM10 at three points in Tbilisi (Kazbegi av., Tsereteli av. and Varketili) for 2017-2024. An analysis of correlations between the specified characteristics of air pollution was carried out. The variability of mean annual values of PM2.5 and PM10 during the observation period under study was studied. In particular, it was found that in 2022-2024, compared to 2017-2019, an average decrease in the concentration of PM2.5 and PM10 was recorded for all observation points. As before, in general, over the entire observation period, the mean annual concentration of PM2.5 and PM10 were above the permissible limit.*

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

Introduction

Over the past sixty years, various studies of atmospheric aerosols have been conducted at the M. Nodia Institute of Geophysics, TSU, including systematic measurements, field work, laboratory experiments, statistical analysis of official data, and theoretical modeling [1–13].

In particular, the results of studies of photochemical smog formation processes in Tbilisi are presented in [1]. The works [4,5] compare the level of aerosol air pollution with PM2.5 and PM10 particles in four populated areas of Georgia – Tbilisi, Batumi, Kutaisi, and Rustavi. The work [10] numerically simulated the change in time and space of the concentration of PM10 scattered in the atmosphere of the city of Kutaisi during the calm period, etc.

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 [11–13].

This work is a continuation of previous studies. Below are the results of statistical analysis of mean monthly and annual concentrations of PM2.5 and PM10 particles in Tbilisi for 2017–2024.

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] are presented.

The data of the 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 three indicated stations are used. Period of observation: January 2017 – December 2024.

In the proposed work the analysis of data is carried out with the use of the standard statistical analysis methods [14]. 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·St Dev/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 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 [15]. In the text below, the dimension of aerosol concentration (mcg/m³) is mostly omitted.

Results and discussion

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

In Table 1 statistical characteristics of mean monthly values of PM2.5 and PM10 in Tbilisi in 2017-2024 are presented. In Fig. 1 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 2017-2024 are presented. In Fig. 2 data about mean annual values of PM2.5 and PM10 in three points in Tbilisi in 2017-2019 and 2022-2024 are presented.

Table 1. Statistical characteristics of mean monthly values of PM2.5 and PM10 in Tbilisi in 2017-2024.

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	14.8	34.1	19.6	45.3	16.1	32.6	16.8	37.3
St Dev	5.6	8.9	7.7	15.8	7.2	9.3	6.6	9.6
C_v, %	37.6	26.2	39.2	34.9	44.8	28.6	39.4	25.8
	Correlation Matrix							
KZBG(PM2.5)	1	0.74	0.90	0.52	0.96	0.83	0.98	0.78
KZBG(PM10)	0.74	1	0.67	0.50	0.65	0.83	0.70	0.85
TSRT(PM2.5)	0.90	0.67	1	0.73	0.90	0.74	0.96	0.85
TSRT(PM10)	0.52	0.50	0.73	1	0.48	0.47	0.60	0.85
VRKT(PM2.5)	0.96	0.65	0.90	0.48	1	0.84	0.98	0.73
VRKT(PM10)	0.83	0.83	0.74	0.47	0.84	1	0.82	0.84
Av(PM2.5)	0.98	0.70	0.96	0.60	0.98	0.82	1	0.81
Av(PM10)	0.78	0.85	0.85	0.85	0.73	0.84	0.81	1

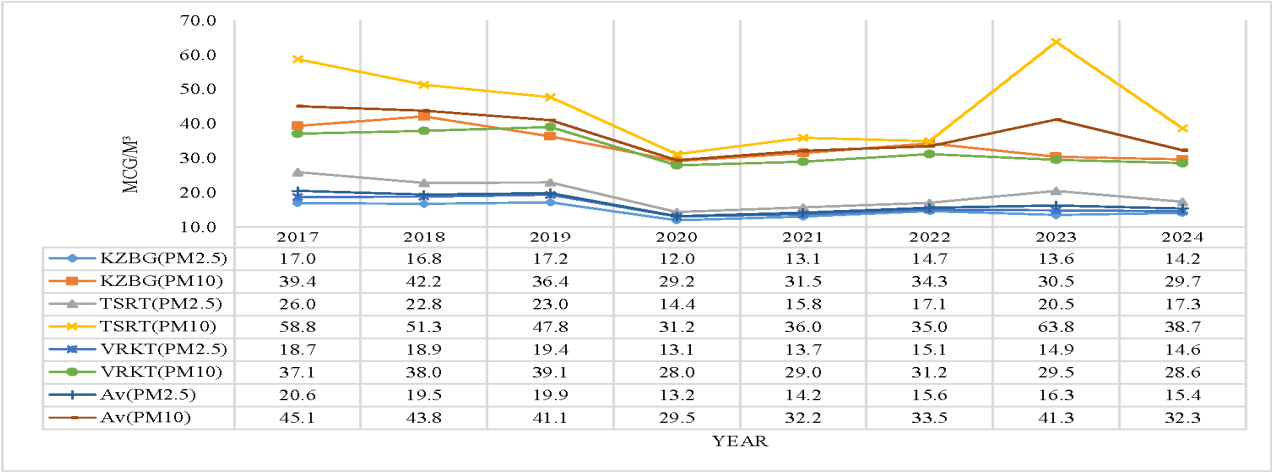


Fig. 1. Time series of mean annual values of PM2.5 and PM10 at three points in Tbilisi and their averaged values for all measurement points in 2017-2024.

In particular, as follows from Table 1 and Fig. 1, in 2017-2024 the range of variability of the average values of PM2.5 for the specified period of time is from 14.8 (KZBG) to 19.6 (TSRT), and PM10 – from 32.6 (VRKT) to 45.3 (TSRT). The smallest variations in PM2.5 values is observed at KZBG (C_v = 37.6%), the largest ones at

VRKT (C_v = 44.8%). The smallest variations in PM10 values is observed at KZBG (C_v = 26.2%), the largest ones at TSRT (C_v = 34.9%). In general, the variations in PM2.5 values are higher than those of PM10.

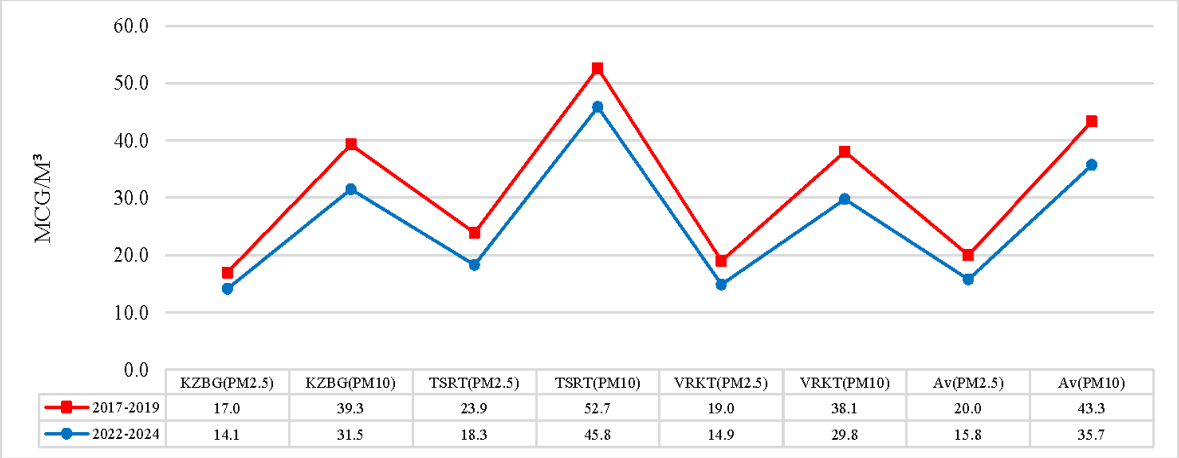
The R value for PM2.5 varies from 0.90 (high correlation, pair TSRT (PM2.5) -VRKT (PM2.5) and pair KZBG(PM2.5) – TSRT (PM2.5)) to 0.98 (very high correlation, pair Av(PM2.5) – KZBG(PM2.5)).

The R value for PM10 varies from 0.47 (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 for individual stations varied from 0.73 (high correlation, TSRT) to 0.84 (high correlation, VRKT). Between Av(PM2.5) and Av(PM10) the R value is 0.78 (high correlation).

The average maximum values of PM2.5 and PM10 for all points (Fig. 2) were observed in 2017 (20.6 and 45.1, respectively), the minimum – in 2020 (13.2 and 29.5, respectively, the period with COVID-19). At the same time, the maximum excess of annual concentrations of PM2.5 and PM10 over their maximum permissible limits was 106 and 126%, respectively, and the minimum was 32 and 47%, respectively.

The PM10/ PM2.5 ratio for KZBG and TSRT is on average 2.3, and for VRKT – 2.0.



	KZBG(PM2.5)	KZBG(PM10)	TSRT(PM2.5)	TSRT(PM10)	VRKT(PM2.5)	VRKT(PM10)	Av(PM2.5)	Av(PM10)
2017-2019	17.0	39.3	23.9	52.7	19.0	38.1	20.0	43.3
2022-2024	14.1	31.5	18.3	45.8	14.9	29.8	15.8	35.7

Fig. 2. Mean annual values of PM2.5 and PM10 in three points in Tbilisi and their averaged values for all measurement points in 2017-2019 and 2022-2024.

In Fig. 2 data about mean annual values of PM2.5 and PM10 in three points in Tbilisi and their averaged values for all measurement points in 2017-2019 and 2022-2024 are presented. As follows from this Figure, in the last three years, compared to 2017-2019, there has been a noticeable decrease in PM2.5 and PM10 concentrations. The greatest decrease in these concentrations is observed in VRKT (by 6.8 and 8.3, respectively), the smallest – in TSRT (by 2.8 and 6.8, respectively).

Conclusion

In the future, as new data accumulates, it is planned to continue similar studies for Tbilisi and other regions of Georgia.

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