Journal of the Georgian *Geophysical Society, e-ISSN: 2667-9973, p-ISSN: 1512-1127*
Physics of Solid Earth, Atmosphere, Ocean and Space Plasma, v. 26 (2), 2023, pp. 51 - 56

PM2.5 and PM10 in the Atmosphere of Kutaisi City

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ABSTRACT

Based on the atmospheric air monitoring data and using experimental measurements there has been assessed concentrations of micro aerosols (PM2.5 and PM10) and features of their time change in the atmosphere of Kutaisi city and its adjacent territories. There have been determined the numbers of days and observation, when their average daily concentrations exceed the respective maximum permissible concentrations. Micro aerosols surface distribution pattern has been built up according to experimental measurements data. Zones of high and low concentrations have been established.

Keywords: atmosphere, pollution, micro aerosols, concentration, monitoring, PM.

Introduction

At the modern stage of social development, under conditions of intensive growth of industry and mobility great importance is attached to protection of atmospheric air purity. This problem is very important in the viewpoint of human health protection, as far as human health is vulnerable to the quality of purity of environment [1-4]. According to the World Health Organization data, in 2016 7.6% of population mortality was caused by atmospheric air pollution [5]. Therefore, study of environment contamination, elaboration of measures focused on its mitigation is a critical mission aimed to protection of ecology and social health. This problem is especially topical for large cities, which are characterized with a great number of pollution sources, diversity of ingredients and high level of contamination.

PM2.5 and PM10 are ranked among main polluting agents of the atmosphere. Due to their small sizes, they easily penetrate human cardio-vascular system, have a strong negative influence on health and cause diseases, which often end up with a lethal outcome [6-8]. Presense of PM2.5 and PM10 in the atmospheric air is stipulated by industrial, agrarian and transport emissions. At the same time, a sharp increase of PM2.5 and PM10 concentrations for several days in the atmosphere of Georgia is mainly caused by synoptic processes, namely large-scale transfer of dust from Sahara and Middle Asia deserts [9].

Monitoring of atmospheric air pollution with PM2.5 and PM10 in Georgian cities has been started in 2017. Routine observations have been made in Tbilisi, Rustavi, Kutaisi and Batumi. Some results of this monitoring have been analyzed in the works [9-21]. Summarized results of studies of air pollution in Kutaisi and its surroundings by particulate matter PM2.5 and PM10 are presented below.

Kutaisi is ranked second among large cities of Georgia. Its population surpasses 147 thousand people. Once a large industrial city, today Kutaisi is an administrative and cultural-recreational center of the Imereti region. Resort city Tskaltubo and many historic monuments, including Gelati monastery complex – a monument of UNESCO cultural heritage, Bagrati Cathedral, Palace of Geguti, Martvili and Motsameta monasteries, as well as touristic attractions – Sataplia and Prometheus caves, Kinchkhi, Martvili, Baldi canyons etc. are located in the city and its surroundings.

Kutaisi is a big transport hub as well. Imereti section of the Great Silk Road passes there and an airport of international importance is located nearby. Hundred of cars move back and forth on its narrow streets. Motor transport traffic is especially intensive in summer and autumn seasons. In its turn, industrial enterprises are presented in relatively less quantity. They are mainly limited by construction, asphalt-concrete and some repair or transport facilities. Socioeconomic function, physical-geographical location, climate and infrastructure of the city determine the necessity of study of ecological situation in Kutaisi.

Proceeding from socioeconomic function of Kutaisi city, study of time change and spatial distribution of PM2.5 and PM10 in its air is a crucial task. The presented article is devoted to the mentioned problem.

Routine observations over PM2.5 and PM10 concentrations in the atmosphere of Kutaisi have been started in 2018 and still proceed at one surveillance station only. This observation point is located at the intersection of L. Asatiani Street and I. Chavchavadze Avenue, at the crossroad with very loaded vehicle traffic (98, L. Asatiani Str.). Observations are carried out by the National Environmental Agency within atmospheric air pollution monitoring plan.

Research method. Data of the Kutaisi monitoring network of the National Environmental Agency and results of experimental measurements conducted by authors are used for assessment of PM2.5 and PM10 concentrations in the atmosphere of Kutaisi city. Experimental measurements were carried out in May and July using the mobile apparatus "Aeroqual Series 500". Concentrations for monitoring network are obtained through one-hour averaging of measured values, while for experimental measurements – via 10-minute averaging.

Research results. In Table 1 there are given the values of microparticles average annual concentrations and number (N) of exceedances of average daily concentrations over 24-hour average maximum permissible concentrations (MPC), which are obtained on the basis of routine measurements conducted in 2018-2020 at the station of air quality monitoring network [9]. It is seen from Table 1 that in the mentioned years the average annual PM2.5 concentration is less than MPC (25 μg/m^3), is minimal in 2020 and maximal in 2019. The qualitatively similar distribution is received for PM10, as well. Its average annual concentration is less than MPC (50 μg/m^3/m^3), is minimal in 2020 (μg/m^3) and maximal in 2019 (49 μg/m^3). Therefore, 2019 year is characterized by maximal exceedances over MPC – 115 observations.

Table 1. Average annual concentration of PM2.5 and PM10 and number (N) of average daily concentration exceedances over MPC

year	2018	2919	2020
PM2.5 (μg/m^3)	16	18	14
PM10 (μg/m^3)	40	49	30
N	68	115	25

In Table 2 there are given the values of average monthly concentrations of microparticles in March-May 2020 and number of exceedances (M) of PM10 average hourly concentrations over MPC.

Table 2. Average monthly concentration of PM2.5 and PM10 and number (M) of PM10 average hourly concentrations exceedances over MPC

Month	March	April	May
PM2.5 (μg/m^3)	12	15	9
PM10 (μg/m^3)	22	38	20
M	34	176	7

It is seen from Table 2 that in the period under review average monthly concentrations of microparticles in Kutaisi city atmosphere don't surpass the respective average daily MPCs. Average monthly concentration of PM2.5 is maximal in April and minimal in May. In case of PM10 we have a qualitatively similar distribution. Its average monthly concentration is relatively high in April (38 μg/m^3). The number of observations, during which the average hourly concentration of PM10 exceeded average daily concentration, was high in April, as well.

In Fig. 1 there are shown the diagrams of micro aerosols average daily concentration change in April-May 2022 measured at air quality monitoring station.

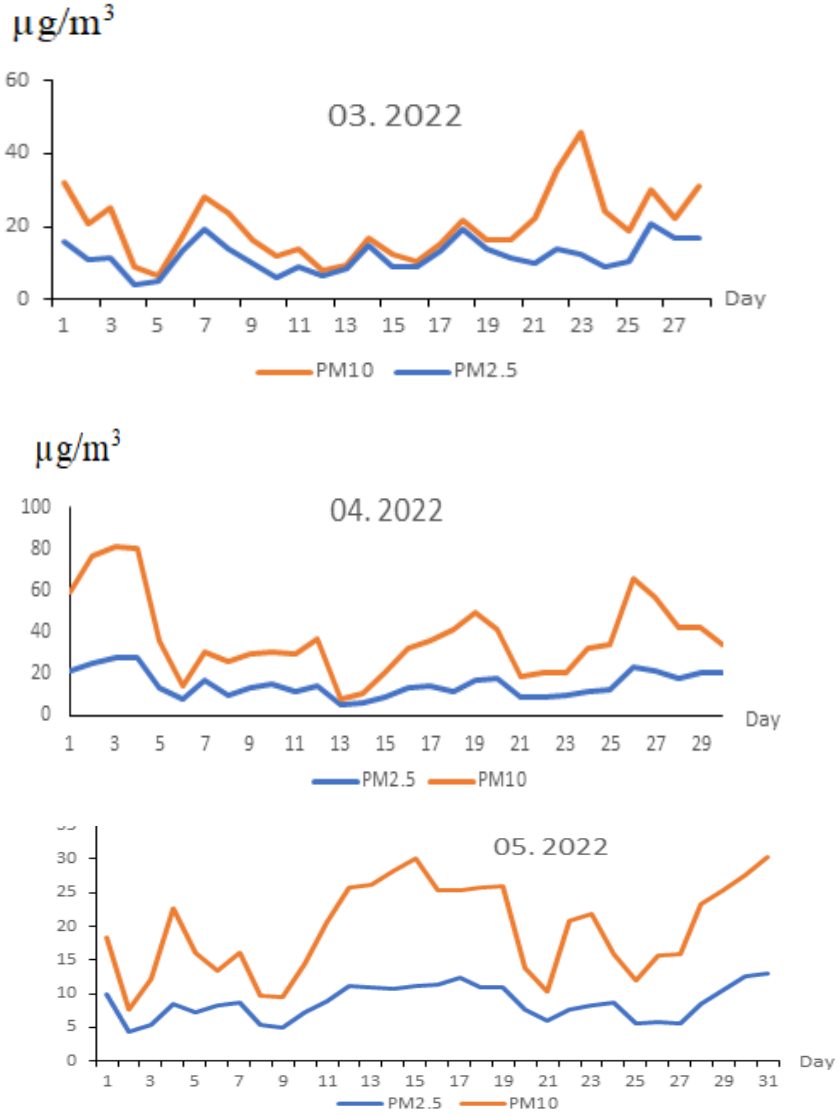

Fig. 1. Values of average daily concentrations of PM2.5 and PM10 in March, April and May 2022 at atmospheric air quality monitoring station

As is seen from Fig. 1, changes of PM2.5 and PM10 average daily concentrations are qualitatively similar. Their local maximum values are observed 3-4 times a month. PM10 concentration always exceeds the respective index of PM2,5 (Fig. 1) and PM10/ PM2.5 ratio is within a range of 0-3.8 (Fig. 2). It is relatively high in April, while in March and May it changes almost in one and the same interval.

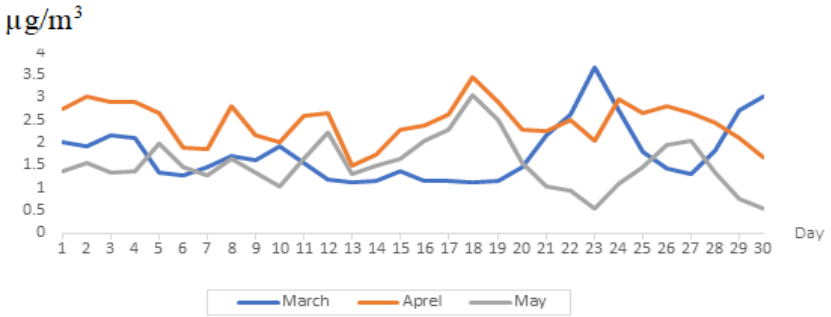

Fig. 2. Ratio of PM10/PM2,5 concentrations in March, April and May, 2022

In May and July, 2023 experimental measurements at the territory of Kutaisi city and its surroundings were carried out under conditions of windless and warm weather at 1.5 m height from the underlying surface.

In Fig. 3 there are shown column diagrams of PM10 and PM2,5 concentrations in the atmospheric air of Kutaisi city and its surroundings. It is seen from Fig. 3 that values of PM10 and PM2,5 concentrations in the observation points are not proportional to each other. In spring and summer PM10 concentrations vary within a range of 8,4-132,5 μg/m^3, while in case of PM2.5 – 4,6-25,1 μg/m^3.

Extremely high PM10 concentration (2,6 MPC) is registered at the territory adjacent to the Avtomshenebeli Street. High concentrations (more than MPC) are fixed in the city center (Green bazaar, Rustaveli Bridge), in the middle part of Tabukashvili Street, and at the intersection of Kutaisi by-pass road and Tabukashvili Street.

Territorial distribution of PM2,5 differs from that of PM10: high concentrations (20-25 μg/m^3) are registered on Gamarjveba Square, in the beginning of Kutaisi-Tskaltubo road and on the Avtomshenebeli Street. In the central part of the city PM2,5 concentrations are within a range of 5-10 μg/m^3.

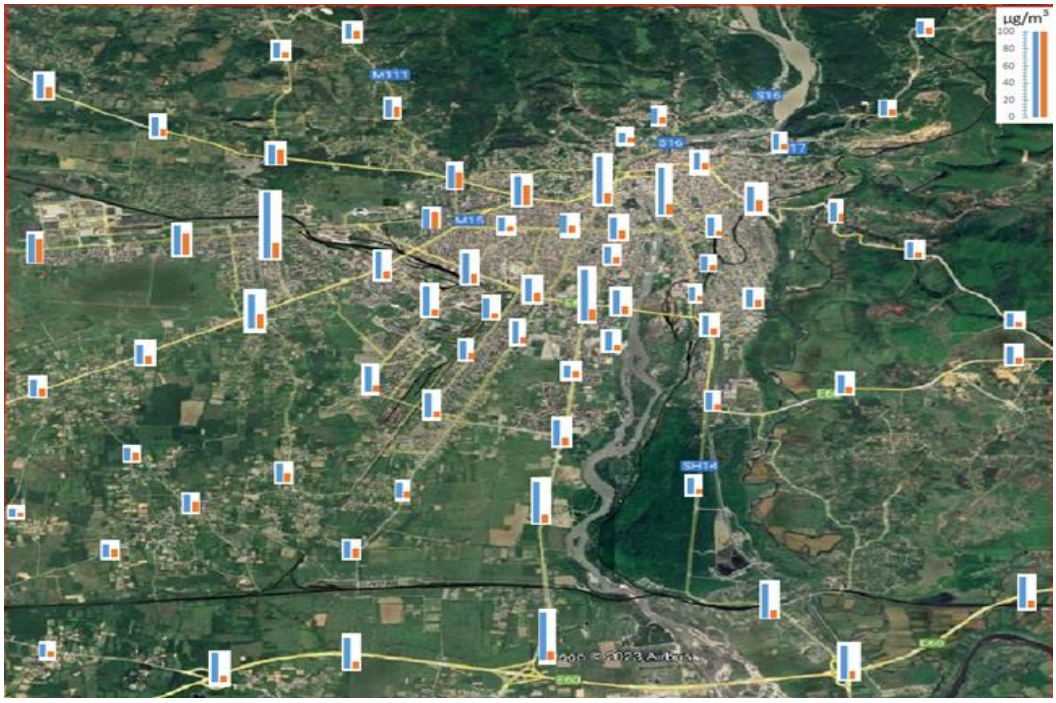

Fig. 3. Values of PM10 and PM2,5 concentrations in Kutaisi city and its surroundings (dark blue – PM10, rose – PM2,5)

PM2,5 and PM10 concentrations were measured in populated localities adjacent to Kutaisi city, as well. The values of their concentrations were as follows: Kvitiri Village – 6 - 12 μg/m^3; Partskhanakevi Village – 4,6 - 8,4 μg/m^3; Geguti Village – 6,2 - 13,9 μg/m^3; Khoni district – 8- 16 μg/m^3; Martvili District – 19 - 23 μg/m^3 (in foggy weather).

Conclusions

Time change of PM2,5 and PM10 concentrations in the atmospheric air of Kutaisi city is analyzed using the data of National Environmental Agency monitoring network. Concentrations are measured in the observation point, which is located at the territory with intensive vehicle traffic – 988, Asatiani Str. Average annual concentration for 2018-2020 and average monthly concentrations for March-May, 2022 are determined. The number of days, when PM10 average hourly concentration exceeds average daily concentrations is established.

Values of PM2,5 and PM10 concentrations in May and July, 2023 are determined in the atmosphere of Kutaisi city and its surroundings and the map of column diagrams for concentration spatial distribution is plotted. The values of maximum and minimum concentrations of micro aerosols, concentration change ranges and areas of relatively heavy and mild contamination of atmospheric air are established.

Acknowledgment: The scientific research is funded and performed within the grant project FR-22-4765 of Shota Rustaveli National Science Foundation.

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PM2.5 და PM10 ქ. ქუთაისის ატმოსფეროში

ა. სურმავა, ვ. კუხალაშვილი, ნ. გიგაური, ლ. ინწკირველი

რეზიუმე

ატმოსფერული ჰაერის მონიტორინგის მონაცემებზე დაყრდნობით და ექსპერიმენტული გაზომვებით შეფასებულია ქ. ქუთაისსა და მის მიმდებარე ტერიტორიაზე ატმოსფეროში მიკროაეროზოლების (PM2.5 და PM10) კონცენტრაციები და მათი დროში ცვლილების თავისებურება. განსაზღვრულია დღეთა და დაკვირვებათა რაოდენობები, როცა მათი საშუალო დღიური შემცველობა აჭარბებს შესაბამის ზღვრულად დასაშვებ კონცენტრაციებს. ექსპერიმენტული გაზომვების მონაცემებით აგებულია მიკროაეროზოლების ზედაპირული განაწილების სურათი. დადგენილია მაღალი და დაბალი კონცენტრაციების ზონები.

საკვანძო სიტყვები: ატმოსფერო, დაბინძურება, მიკრო აეროზოლები, კონცენტრაცია, მონიტორინგი, PM.

PM2.5 и PM10 в атмосфере г. Кутаиси

А. Сурмава, В. Кухалашвили, Н. Гигаури, Л. Инцкирвели

Резюме

На основе данных мониторинга атмосферного воздуха и экспериментальных измерений в атмосфере г. Кутаиси и его окрестностей оценены концентрации микроаэрозолей (PM2,5 и PM10) и особенности их изменения с течением времени. Определены количество дней и период наблюдений, когда их среднесуточное содержание превышает значения соответствующих предельно допустимых концентраций. На основе данных экспериментальных измерений построена картина поверхностного распределения микроаэрозолей. Установлены зоны повышенных и пониженных концентраций.

Ключевые слова: атмосфера, загрязнение, микроаэрозоли, концентрация, мониторинг, PM.