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Results of a Study on the Impact of Surface Ozone Concentration on the Spread of COVID-19 in Tbilisi

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ABSTRACT

The results of a study of the influence of diurnal values of surface ozone concentration (SOC) on the infection positivity rate with coronavirus COVID-19 (IR) of the population of Tbilisi from October 8, 2020 to May 31, 2021 are presented. It was found that IR values are inversely correlated with SOC. For example, at ozone concentrations from 0 to 20 mcg/m^3 values of COVID-19 Infection Rate on average was 18.5 %, whereas with SOC values from 80 to 100 mcg/m^3 – only 2.3%. Connection daily values of IR with SOC has an inverse linear form. IR = -0.2307·SOC + 20.543 for individual cases; IR = -0.2113·SOC + 19.756 for averaged values of IR in different ranges of SOC values.

Key Words: *surface ozone concentration, COVID-19, infection positive rate.*

Introduction

Four years have passed since the outbreak of the new coronavirus (COVID-19) in China, which was recognized on March 11, 2020 as a pandemic due to its rapid spread in the World [1]. During this period of time, despite the measures taken (including vaccination), several strains of this virus appeared. The overall level of morbidity and mortality is currently declining significantly, although in many countries of the world it remains quite high.

According to [2] globally, the number of new cases increased by 52% during the 28-day period of 20 November to 17 December 2023 as compared to the previous 28-day period, with over 850 000 new cases reported. The number of new deaths decreased by 8% as compared to the previous 28-day period, with over 3000 new fatalities reported. As of 17 December 2023, over 772 million confirmed cases and nearly seven million deaths have been reported globally.

During the period from 13 November to 10 December 2023, over 118 000 new COVID-19 hospitalizations and over 1600 new intensive care unit (ICU) admissions have been recorded with an overall increase of 23% and 51% respectively amongst the countries reporting consistently within the current and past reporting periods.

As of 18 December 2023, JN.1, a sub-lineage of BA.2.86 Omicron variant has been designated a separate variant of interest (VOI) apart from its parent lineage BA.2.86 due to its rapid increase in prevalence in recent weeks. Globally, EG.5 remains to be the most reported VOI.

Regarding Georgia, from February 27, 2020 to September 30, 2022 in this country 1785137 new cases of COVID-19 infection were registered; died - 16912 people. Due to the sharp decline in coronavirus infection in Georgia after September 30, 2022, official statistics on COVID-19 are not published [3].

Researchers and specialists in various fields of sciences from all over the world, together with epidemiologists and doctors, have engaged in intensive research into this unprecedented phenomenon (including in Georgia [3-11]), providing them with all possible assistance. In particular, in our early work [10] it was noted that in 2021, work on statistical analysis, forecasting, systematization of forecasts, spatio-temporal modeling of the spread of the new coronavirus, etc. is actively continuing. Similar work continues in 2022 [11-14]. Our latest work [15] presents the results of a statistical analysis of daily, total by day of the week and monthly data on officially registered deaths from the new coronavirus COVID-19 in the countries of the South Caucasus (Armenia, Azerbaijan, Georgia). from March 12, 2020 to May 31, 2022 are presented.

A significant number of papers are devoted to studies of the influence of various meteorological factors (included surface ozone) on the COVID-19 pandemic [15-31].

In our last papers [23,24] results of a study of the influence of diurnal values of separate components of simple thermal indices (temperature and air relative humidity, wind speed) on the infection positivity rate with coronavirus COVID-19 (IR) of the population of Tbilisi from September 1, 2020 to May 31, 2021 are presented. It was found that IR values are inversely correlated with air temperature and wind speed, and positively correlated with air relative humidity. The effect of four different thermal indices (air effective temperature and Wet-Bulb-Globe-Temperature) on the IR values averaged over the scale ranges of their categories was studied. It has been found that an increase of the air effective temperature leads to a decrease of the IR values. In the latter case, the level of significance of the relationship between thermal indices and IR values is much higher than in the case of the relationship between IR and separate components of these indices. In work [24] results of a study of the influence of diurnal values of Angstrom Fire Index (AFI, temperature and air relative humidity combination) on the infection positivity rate with coronavirus COVID-19 (IR) of the population of Tbilisi over the same period of time are presented. It was found that an increase in AFI values (reduction of fire danger) leads to an increase in IR. Thus, with the “Low” fire danger category, the IR value averaged 11.5%, and with the “Extreme” category - 3.5%. The relationship between the AFI and IR values has the form of a second power polynomial. Thus, AFI also manifests itself as a bioclimatic indicator. In the future, it is planned to compare AFI values with various indicators of human health.

As for the effect of ground-level ozone concentration on the spread of Covid-19, research data is ambiguous. For example, in papers [26,27] note a direct connection between the concentration of ground-level ozone and the spread of the covid-19 virus. In the works [28-31] note the presence of a feedback between ozone and the spread of the Covid-19 viral infection.

In the work [30] shown, that as of September 10, 2020, over 70,000 cases and over 2,000 deaths have been recorded in Poland. Of the many factors contributing to the level of transmission of the virus, the weather appears to be significant. In this work authors analyze the impact of weather factors such as temperature, relative humidity, wind speed and ground level ozone concentration on the number of COVID-19 cases in Warsaw, Poland. The obtained results show an inverse correlation between ground level ozone concentration and the daily number of COVID-19 cases.

The results of [28] show that in four major metropolitan areas in Italy during a strict lockdown because of COVID-19 pandemic implemented by the Italian government, COVID-19 pandemic–related infections are slowed down by higher tropospheric ozone concentrations and eased by the atmospheric particulate. Authors quantitatively assessed that higher levels of tropospheric ozone, already proven effective against viruses and microbial contaminants, play a role in flagging COVID-19 pandemic transmission.

In study [31] examined the relationship between new daily cases, ground-level ozone, temperature, relative humidity, and wind speed. Temperature was found to have the strongest correlation with new cases, an inverse correlation. Ozone did have a significant inverse correlation with cases, but is highly autocorrelated with temperature. The author believes that would require much more in-depth analysis techniques- and more data- to tease out a definitive connection.

We also continue to conduct similar studies. The results of a study of the influence of diurnal values of Surface Ozone Concentration on the infection positivity rate with coronavirus COVID-19 of the population of Tbilisi from October 8, 2020 to May 31, 2021 are presented below.

Material and methods

Data of Agency on the Environment of Georgia about the daily mean Surface Ozone Concentration (SOC, mcg/m^3) for three point of Tbilisi (Kazbegi av., Tsereteli av. and Varketili) during October 8, 2020 to May 31, 2021 were used in the work [32; https://air.gov.ge/en/reports_page]. For the same days, data of National Center for Disease Control and Public Health of Georgia about infection positivity rate with coronavirus COVID-19 (IR) of the population of Tbilisi were used (IR = Confirmed Coronavirus Cases/Test Number, %).

The paper compares the mean daily values of SOC with the IR values. Data analysis was carried out using standard methods of mathematical statistics [33].

The following designations will be used below: Mean – average values; Min – minimal values; Max - maximal values; St Dev - standard deviation; σ_m – standard error; C_V = 100·St Dev/Mean – coefficient of variation, %; R^2 – coefficient of determination; R – coefficient of linear correlation; α – level of significance.

The degree of correlation was determined in accordance with [33]: very high correlation ($0.9 \le R \le 1.0$); high correlation ($0.7 \le R < 0.9$); moderate correlation ($0.5 \le R < 0.7$); low correlation ($0.3 \le R < 0.5$); negligible correlation ($0 \le R < 0.3$).

Results and discussion

Results in Fig. 1-4 and Table 1-2 are presented.

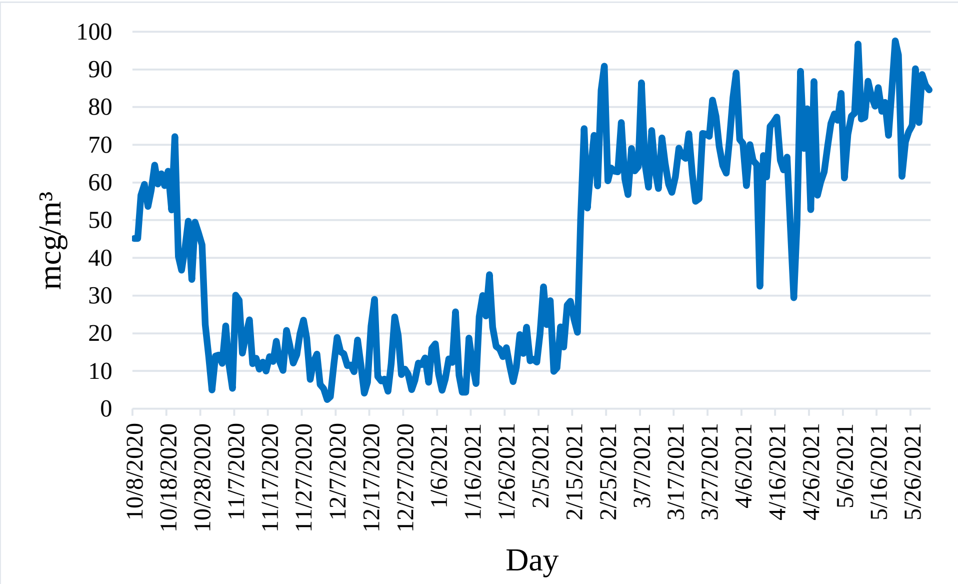

Fig. 1. Time-series of SOC in Tbilisi from October 8, 2020 to May 31, 2021.

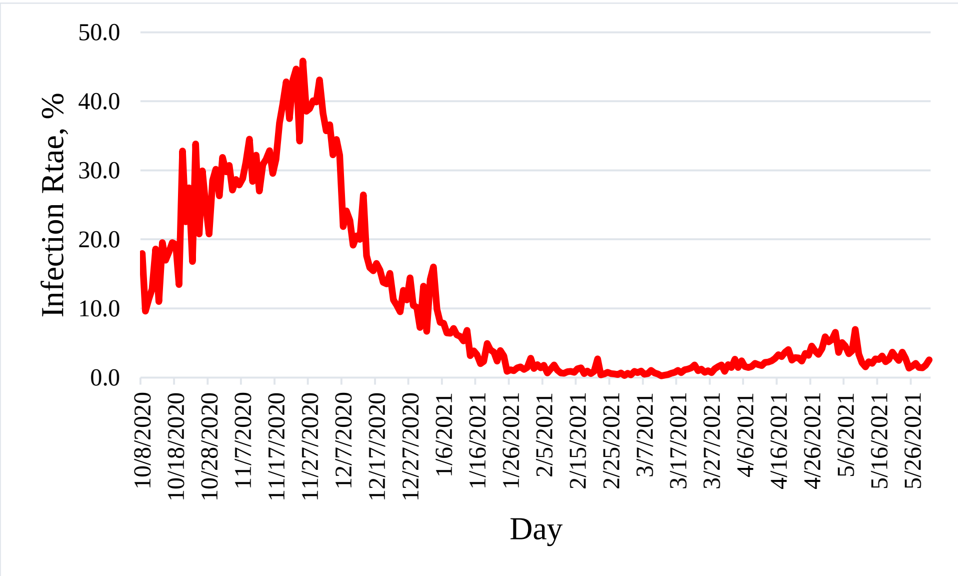

Fig. 2. Time-series of IR in Tbilisi from October 8, 2020 to May 31, 2021.

In Fig. 1-2 time-series of SOC and IR in Tbilisi from October 8, 2020 to May 31, 2021 are presented.

In Table 1 statistical characteristics of daily values of SOC and IR in Tbilisi for the time period under study are presented.

Table 1. Statistical characteristics daily values of SOC and IR in Tbilisi.

Variable	Mean	Max	Min	St Dev	σ_m	C_v, %	Count
SOC	42.6	97.6	2.4	28.5	1.9	66.9	236
IR	10.7	45.8	0.2	12.6	0.8	117.7	

In particular, as follows from Fig. 1-2 and Table 1, the range of variability of the studied parameters is as follows: SOC – from 2.4 to 97.6 mcg/m^3; IR – from 0.2 to 45.8 %. Mean value of SOC is 42.6±1.9 mcg/m^3 and IR – 10.7±0.8 %.

Connection daily values of IR with SOC has an inverse linear form. For individual cases IR = -0.2307·SOC + 20.543 (R=0.52, α<0.005, moderate correlation).

In Fig. 3 data about values of COVID-19 Infection Rate under different surface ozone concentration is presented. In Table 2 statistical characteristics of daily values of SOC and IR in Tbilisi in different ranges of SOC values are presented.

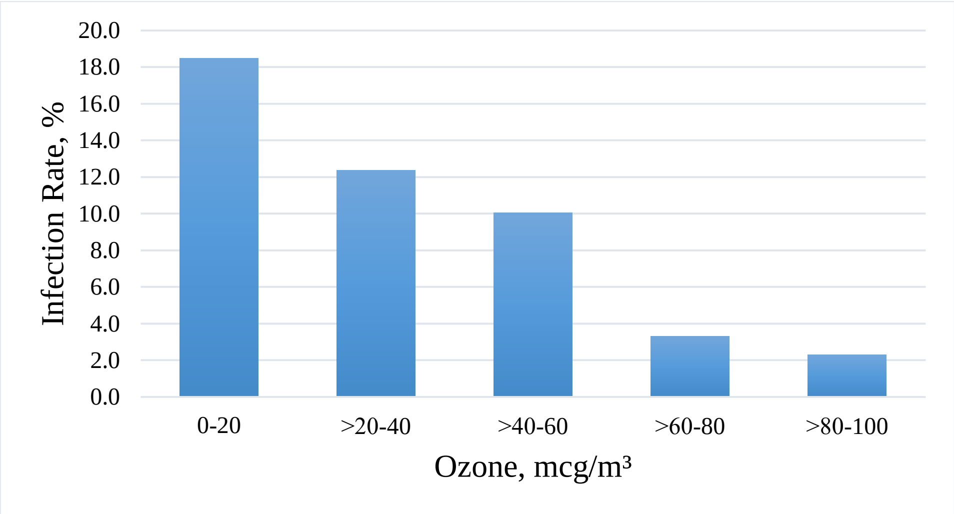

Fig. 3. Values of COVID-19 Infection Rate under different surface ozone concentration.

Table 2. Statistical characteristics of daily values of SOC and IR in Tbilisi in different ranges of SOC values.

SOC	Variable	Mean	Max	Min	St Dev	σ_m	C_v (%)	Count
0-20	SOC	11.7	19.9	2.4	4.4	0.5	37.6	86
	IR	18.5	45.8	0.7	14.0	1.5	75.9	
>20-40	SOC	26.5	36.8	20.3	4.7	0.9	17.9	29
	IR	12.4	43.1	0.6	13.7	2.6	110.6	
>40-60	SOC	53.1	59.6	40.4	5.8	1.1	10.9	30
	IR	10.0	33.8	0.2	10.0	1.9	100.1	
>60-80	SOC	69.2	79.6	60.1	5.8	0.7	8.4	69
	IR	3.3	32.8	0.3	5.2	0.6	157.5	
>80-100	SOC	86.9	97.6	80.2	4.7	1.0	5.4	22
	IR	2.3	5.1	0.4	1.1	0.2	48.7	

For example, at ozone concentrations from 0 to 20 mcg/m^3 values of COVID-19 Infection Rate on average was 18.5 %, whereas with SOC values from 80 to 100 mcg/m^3 – only 2.3% (Fig. 3, Table 2).

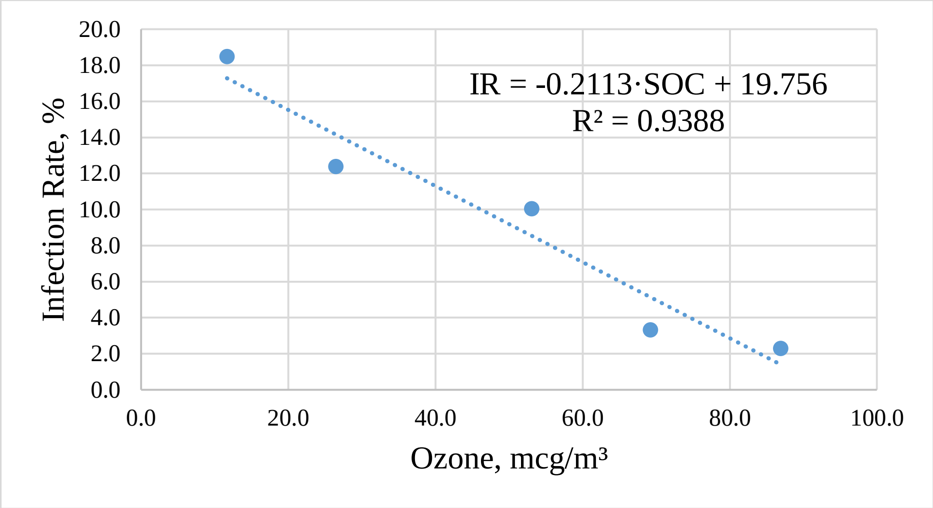

Fig. 4. Linear correlation between daily values of COVID-19 Infection Rate and Surface Ozone Concentration in Tbilisi from October 8, 2020 to May 31, 2021 (α<0.005, very high correlation).

Connection daily values of IR with SOC for averaged values of IR in different ranges of SOC values in Fig. 4 is presented. Same as for individual cases, this connection has an inverse linear form, but with a much higher level of correlation (very high correlation).

Thus it has been found that an increase of the Surface Ozone Concentration leads to a decrease of the IR values (both for individual and averaged values of the studied parameters). In the latter case, the level of significance of the relationship SOC and IR values is much higher than for the individual cases. The reason for this (as in for thermal indexes [23-25]) may be that often with a small number of tests, overestimated IR values obtained (testing is carried out only for visitors with coronavirus symptoms. When data are averaged these shortcomings are smoothed out. Accordingly, the above results were obtained.

Conclusion

The spread of COVID-19 in Tbilisi, as in other parts of the world, significantly depends on both individual meteorological factors and their complexes (thermal indicators), and the level of air pollution (including ozone concentration). As many researchers note, this dependence is often ambiguous and in many cases is determined by local climatic and other specific conditions, the type of virus, etc. In the future, we will continue this research both for Tbilisi and for other regions of Georgia.

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თბილისში COVID-19-ის გავრცელებაზე მიწისპირა ოზონის კონცენტაციის გავლენის კვლევის შედეგები

ა. ამირანაშვილი, ნ. ჯაფარიძე, ჯ. ხარჩილავა, კ. ხაზარაძე, ა. რევიშვილი

რეზიუმე

წარმოდგენილია მიწისქვეშა ოზონის კონცენტრაციის (SOC) დღიური მნიშვნელობების ქალაქ თბილისის მოსახლეობის კორონავირუსით ინფიცირების დადებითობის მაჩვენებელზე COVID-19 (IR) კვლევის შედეგები 2020 წლის 8 ოქტომბრიდან 2021 წლის 31 მაისამდე. აღმოჩნდა, რომ IR მნიშვნელობები საპირისპირო კორელაციაშია SOC-თან. მაგალითად, ოზონის კონცენტრაციებისთვის 0-დან 20 მკგ/მ^3-მდე, COVID-19 ინფექციის პოზიტიურობის მაჩვენებელი საშუალოდ შეადგენდა 18.5%-ს, ხოლო SOC-ის მნიშვნელობებისთვის 80-დან 100 მკგ/მ^3-მდე იყო მხოლოდ 2.3%. ყოველდღიურ IR მნიშვნელობებსა და SOC-ის შორის ურთიერთობას აქვს შებრუნებული წრფივი ფორმა. IR = -0,2307·SOC + 20.543 ინდივიდუალური შემთხვევებისთვის; IR = -0,2113·SOC + 19.756 - საშუალო IR მნიშვნელობებისთვის SOC-ის მნიშვნელობების სხვადასხვა დიაპაზონში.

საკვანძო სიტყვები: მიწისპირა ოზონის კონცენტრაცია, COVID-19, დადებითობის მაჩვენებელი.

Результаты исследования влияния концентрации приземного озона на распространение COVID-19 в Тбилиси

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Резюме

Представлены результаты исследования влияния суточных значений концентрации приземного озона (SOC) на показатель положительности инфицирования коронавирусом COVID-19 (IR) населения города Тбилиси за период с 8 октября 2020 года по 31 мая 2021 года. Было обнаружено, что значения IR обратно коррелируют с SOC. Например, при концентрациях озона от 0 до 20 мкг/м^3 показатель положительности инфицирования коронавирусом COVID-19 в среднем составлял 18.5 %, тогда как при значениях SOC от 80 до 100 мкг/м^3 – всего 2.3%. Связь суточных значений IR с SOC имеет обратную линейную форму. IR = -0.2307·SOC + 20.543 для отдельных случаев; IR = -0.2113·SOC + 19.756 для усредненных значений IR в разных диапазонах значений SOC.

Ключевые слова: концентрация приземного озона, COVID-19, показатель положительности.