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Dynamics of the mortality of the population of Tbilisi City and its connection with the surface ozone concentration

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Abstract

Results of detailed statistical analysis of the changeability of mortality on 1000 inhabitants (M) of the population of Tbilisi city in 1984-2010 are represented. The characteristics of the indicated time series is studied (autocorrelation, trend, random components, etc.). In particular, the values of M varies from 8.03 to 12.35, the changeability of mortality is described by the fifth order power polynomial, etc. The influence of the content of surface ozone on the mortality is studied. It is shown, that under the conditions of Tbilisi city the concentration of surface ozone 50 mcg/m^3 and above very negative influences the health of people and it leads to an increase in the mortality.

Key words: *mortality, trend, surface ozone concentration, air pollution*

Introduction

It is known that the mortality of population is closely related to social, economic, ecological and other conditions. In connection with similar that indicated special attention is paid to studies in different countries. In the last 20 years in Georgia several times were observed political, social and economic shakings (war, unstable political situation, the sharp oscillations of economic development, etc.). As a whole, within the indicated period of time an increase in the mortality of population was observed. Although, in recent years in the dynamics of mortality a certain stabilization and even positive tendencies are observed (decrease) [1,2].

As it was noted above by one of the important factors, which cause the mortality of population, appears ecological situation, including – air pollution. In the large cities the pollution of atmosphere is frequently connected with the presence of a smog of different types. One of the types of smog is the so-called photochemical smog [3].

Photochemical smog can't be detected by apparatus. It is the joint phenomena, i.e. result of action of many variables (factors). Ground high concentration of ozone is a characterizing attribute of photochemical smog. Ozone is not formed directly during burning of fuel, and is secondary pollutant.

Besides in photochemical smog there are reactions between oxides of nitrogen and the burned organic compounds. With participation of ozone actively there is a reaction for formation of so-called secondary aerosols of the submicron sizes under the scheme gas → particle (sulfates, nitrates, etc.). In products of these reactions there are many cancerogenic substances. Thus, photochemical smog represents multi component mix of primary and secondary formation of gases and aerosols. The basic components of smog are: ozone, oxides of nitrogen and sulfur, organic compounds of dioxide nature which in aggregate is referred to as photos-oxidants.

Photochemical smog reduces visibility, fatally acts on plants, negatively acts on human health, can cause damage of respiratory ways, vomiting, excitation of a mucous membrane of an eye and the general malaise. In photochemical smog there can be such compounds of nitrogen which increase probability of occurrence of malignant diseases. Intensive and long smog can become the reason of growth of disease and death rate. As ozone shows strongly oxidizing properties, it negatively acts on human health and destructively acts on many materials.

Thus, with the photochemical smog on the health of people simultaneously act both the high concentrations of the primary and secondary contaminators of the atmosphere (gases and aerosols) and the high concentrations of surface ozone. In this case the high concentrations of ozone are also the indicator of the high atmospheric content of other forming ozone admixtures. With the smog of other types ozone concentration is low, and its action on the health of people is insignificant [4-8].

The first officially registered case of atmospheric pollution which had serious consequences was in the Donor (USA) in 1948. During 36 hours has died twenty people, and hundreds inhabitants felt badly. After four years, in December, 1952, in London has occurred more tragic case. In consequence of air pollution during five days has died 4000 people. Though the next years both in London and in other cities repeatedly were strong smog but such catastrophic case have not repeated.

According to the data of the World Health Organization (WHO), lasting pollution of air by the machines in Austria, Switzerland and France is the reason for premature death more than 21 000 people yearly, in essence, from the diseases of the heart and respiratory tract. This index exceeds a quantity of people, which yearly perish in these 3 countries with the road- transport incidents. In eight the largest cities of world yearly it could it takes away the lives of 3500 people. In 5% of cases the poisons, which are contained in air, are the reason for lethal outcome. In Europe each year the victims of the pollution of the atmosphere become, at least, 100 thousand people. In USA a quantity of victims reaches 70 thousands. So many people they die from cancer of light and prostate [9 - 11].

In Georgia the first observation of ground ozone have begun in 1980 in Tbilisi in Institute of Geophysics of the Academy of Sciences of Georgia. From 1984 to this day these observations have regular nature [4,5,12,13]. To this day are carried out many scientific researches. Thus, according to average monthly data of 1980-1990 it is obtained that in Tbilisi because of the high concentrations of ozone into the cold half-year occurs an increase in the mortality for reasons of heart - vascular diseases to 5%, and into and the warm - to 9% [14].

Work presents the analysis of the dynamics of the common annual mortality of the population of Tbilisi city taking into account contemporary conditions (period from 1984 through 2010) and the evaluations of the influence on it of the concentration of surface ozone. Also the preliminary evaluations of the influence of ozone concentrations on the daily mortality of the population of Tbilisi city in 2009-2010 are given.

Method and data description

In the work the data of National Statistics Office of Georgia about the common mortality (1984-2010) , and data of the Emergency Care Medical Centre of Tbilisi City Hall about the daily mortality (2009-2010) of the population of Tbilisi city are used [1,2]. The common annual mortality of population to 1000 inhabitants is normalized.

The measurements of ozone were conducted by the electro chemical ozone instrument OMG-200. Observational data for 15 hours are presented [12,13]. The unit of the ozone measurement is mcg/m^3.

In the proposed work the analysis of data is carried out with the use of the standard statistical analysis methods of random events and methods of mathematical statistics for the non accidental time-series of observations [15, 16].

The following designations will be used below: M – mortality, SOC - surface ozone concentration, Min – minimal values, Max - maximal values, Range - variational scope, Range/ Mean (%) - relative variational scope, σ - standard deviation, σ_m - standard error (68% - confidence interval of mean values), C_v - coefficient of variation (%), A - coefficient of skewness, K - coefficient of kurtosis, R - coefficient of linear correlation, R_i - index of correlation, R^2 – coefficient of determination, R_s – Spearman's rank correlation coefficient, R_k – Kendall's rank correlation coefficient, R_a - autocorrelation coefficient, K_{DW} – Durbin-Watson statistic, t - Stiudent criterion, α - the level of significance.

Results of detailed statistical analysis of the changeability of mean annual values of SOC in Tbilisi in 1984-2010 in [13] are represented. In particular, the changeability of the indicated time series is described by the fourth power polynomial. An increase in the SOC in the period from 1984 through 1995-1997 was observed, then - decrease. Thus, in average: in 1984 SOC = 37 mcg/m^3, into 1998 – 58 mcg/m^3, into 2010 – 40 mcg/m^3. Data about daily SOC in Tbilisi in 2009-2010 in the work [12] is presented.

Results

The results are given in Tables 1-4 and Fig. 1-4.

Analysis of the mortality dynamics in 1984-2010.

Table 1. The statistical characteristics of mortality on 1000 inhabitants in Tbilisi in 1984-2010

Standard statistics of time series			
Mean	10.30	**σ_m**	0.25
Min	8.03	**C_v (%)**	12.6
Max	12.35	**A**	-0.58
Range	4.32	**K**	-0.64
Median	10.61	**σ_m /Mean (%)**	2.43
σ	1.30	**Range/ Mean (%)**	41.9
The non-randomness characteristic of time series			
Correlation with year		**Trend + background ($Y = a\cdot X^5 + b\cdot X^4 + c\cdot X^3 + d\cdot X^2 + e\cdot X + f$)**	
R with year	0.62	**a**	-0.0000278
(α) R	0.01	**b**	0.00206
R_k	0.305	**c**	-0.05523756
(α) R_k	0.026	**d**	0.62867
R_s	0.48	**e**	-2.528
(α) R_s	0.015	**f**	10.277
R_a, Lag = 1	0.842	**R_i**	0.93
(α) R_a	0.001	**(α) R_i**	0.001
K_{DW}	0.4	**K_{DW}**	1.45
(α) K_{DW}	Not significance	**(α) K_{DW}**	0.05
Standard statistics of trend + background and random components			
Trend + background		**Random components**	
Mean	9.66	**Mean**	0.65
Min	7.02	**Max**	1.60
Max	10.85	**σ**	0.49
Range	3.83	**C_v (%)**	75.2
σ	10.14	**Range/ Mean (%)**	247
C_v (%)	1.21	**Share of real data**	6.3
Range/ Mean (%)	39.6		
Share of real data	93.7		

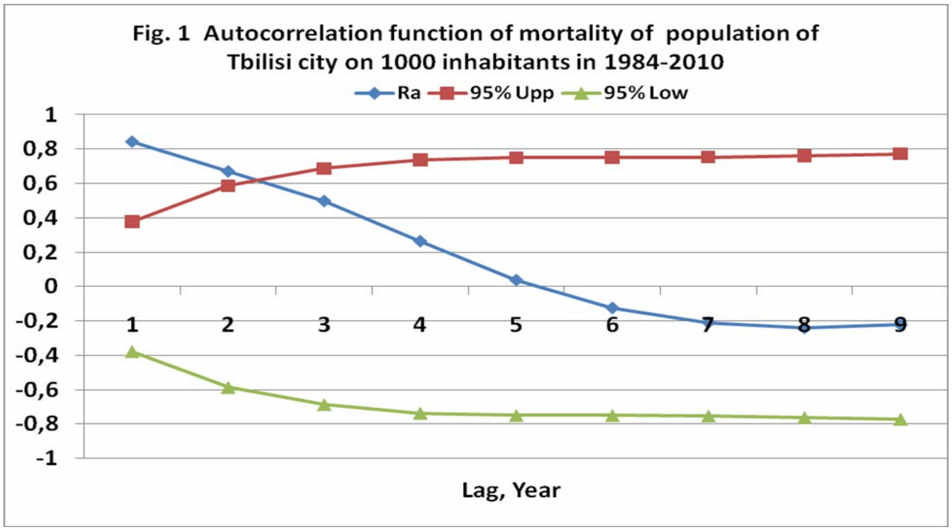
The standard statistical characteristics values of M in the upper part of table 1 are represented.

As follows from this table the values of M varies from 8.03 to 12.35, variational scope is 4.32, mean value - 10.30, median - 10.6, standard deviation - 1.30, standard error - 0, coefficient of variation 12.6%.

Coefficient of skewness is -0.58, coefficient of kurtosis - -0.64. The absolute values of the calculated coefficients of skewness and kurtosis are less than the trebled theoretical value of their standard deviations. Accordingly in general set of function of distribution of M should be close to normal. The relative variational scope is 41.9 %.

The non-randomness characteristic of the time series of M in the middle part of table 1 are submitted.

Coefficient of linear correlation between M and years is 0.62 , the value of Kendall's rank correlation coefficient is 0.305, the value of Spearmen's rank correlation coefficient is 0.48, the value of autocorrelation coefficient with a Lag = 1 year is 0.842. The values of level of significance α for the above mentioned parameters of stability also are given in this table.

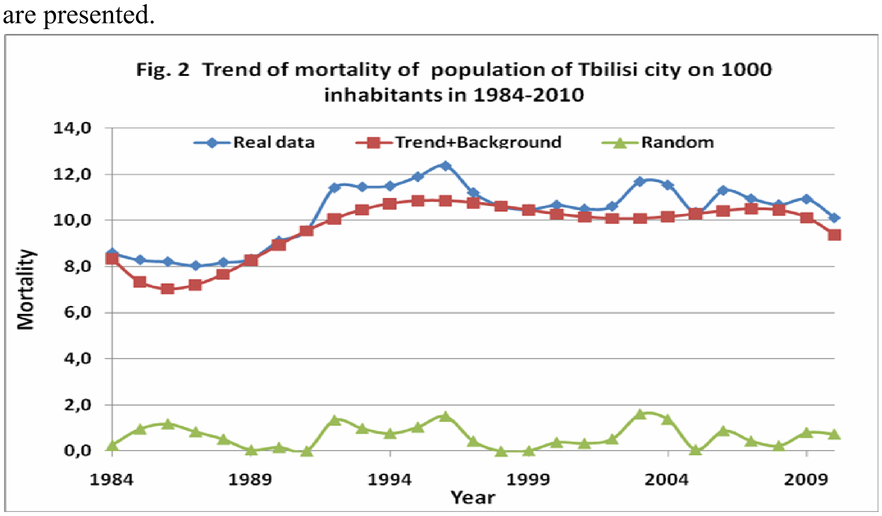


The value of autocorrelation function of M is significance in the limits of two lag (fig. 1). This can be caused by the strong influence of external factors (including of environment) on the changeability of M.

At first glance it can seem that the trend of M takes the linear form. However, in the case of linear trend the analysis of residual component shows their auto-correlation (K_{DW} = 0.4, not significance). Thus, the time series of M is autocorrelate and trend has a nonlinear nature.

As showed analysis, the trend of values M takes the form of the polynomial of fifth degree (**R_i** = 0.93, K_{DW} = 1.45, table 1).

The statistical characteristic of trend + background and random components of M in the low part of table 1 and fig. 2 are presented.



The average value of trend + background component of M is 9.66, the minimal value - 7.02, maximal - 10.85, the relative variational scope - 39.6 %. A share of the mean values of the component of trend+background from the mean value of real data of M constitute 93.7 %.

The average value of random component of M is 0.65, the maximal - 1.60, the relative variational scope - 247 % . A share of the mean value of the random component from the mean value of real data of M constitute 6.3 %. Thus, the changeability of values M in the investigated period practically caused by its trend component.

Analysis of the connections between mean annual maximum surface ozone concentration and annual mortality in Tbilisi in 1984-2010.

The absence of the clearly expressed tendencies in the changeability of SOC and M (increase or decrease) makes it possible to carry out the correlation and regression analysis of the connection between their real data. The results of this analysis in tables 2-3 and fig. 3 are given.

Table 2. Correlation between mean annual surface ozone concentration in 15 hour and mortality of population of Tbilisi city on 1000 inhabitants in 1984-2010

R	**(α) R**	**R_k**	**(α) R_k**	**R_s**	**(α) R_s**
0.39	0.1	0.2	0.14	0.33	0.1

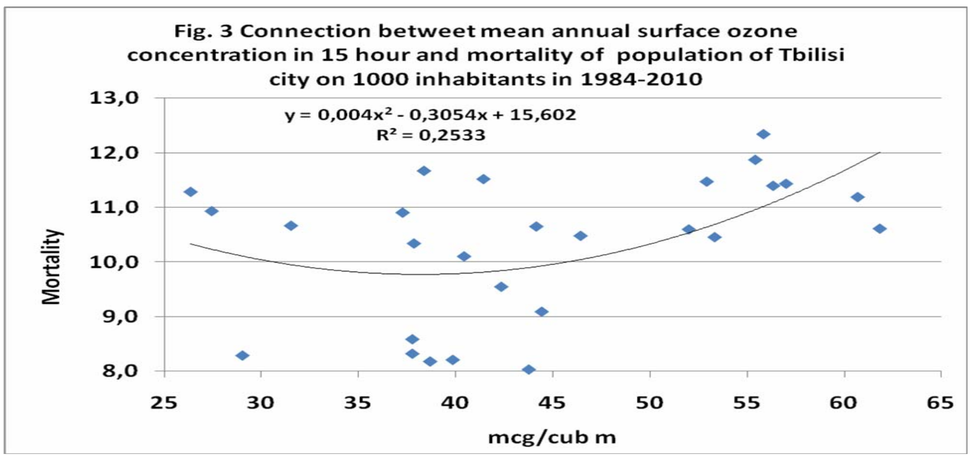


Table 3. Effect of the mean annual surface ozone concentration in 15 hour on the mortality of population of Tbilisi city in 1984-2010

Range of ozone concentration mcg/m³	**Mean ozone concentration mcg/m³**	**Mean mortality on 1000 inhabitants**	**Range of ozone concentration mcg/m³**	**Mean ozone concentration mcg/m³**	**Mean mortality on 1000 inhabitants**
26.3-46.4	38	9.82	52.0-61.6	56.2	11.27
Increase in the mortality on 1000 inhabitants	**Stiudent criterion t**	**(α) t**	**Mean mortality on 1000 inhabitants in 1984-2010**	**Share of the increase in the mortality of mean mortality (%)**	**Mean annual increase in the mortality on population of Tbilisi city**
1.45	3	0.01	10.3	14.1	1680

As follows from table 2 between the values SOC and M the significant correlation is observed. This connection takes the form of the second power polynomial (fig. 3).

In table 3 the estimation of effect of mean annual surface ozone concentration in 15 hour on the mortality of population of Tbilisi city are presented.

As follows from this table in the years, when ozone concentration on the average was equal to 56.2 mcg/m^3 (range from 52 mcg/m^3 to 61.6 mcg/m^3) value of mortality to 1000 inhabitants was equal to 11.27. When ozone concentration on the average was equal to 38 mcg/m^3 (range from 26.3 mcg/m^3 to 46.4 mcg/m^3) mortality to 1000 inhabitants was equal to 9.82.

Thus, the increased of surface ozone concentrations (and its accompanying harmful for the health people the components of smog) on the average increase yearly mortality of the inhabitants of Tbilisi city by 1680 people. This is equal to 14.1 % of entire average annual mortality of the population of Tbilisi city, which is approximately 3 times higher than the same indices for the advanced countries.

Analysis of the connections between daily maximum surface ozone concentration and daily mortality in Tbilisi in 2009-2010.

Results of the evaluation of effect of the surface ozone concentration on the mortality of population of Tbilisi city in 2009-2010 in fig. 4 and table 4 are presented. As follows from fig. 4 connection between surface ozone concentration in 15 hour and daily mortality in Tbilisi has the form of the second power polynomial.

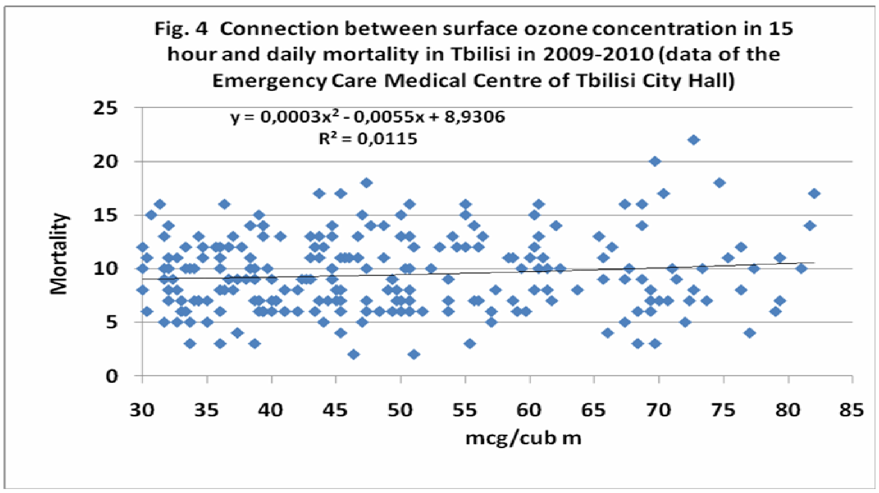


Table 4. Effect of the surface ozone concentration in 15 hour on the daily mortality of population of Tbilisi city in 2009-2010 (data of the Emergency Care Medical Centre of Tbilisi City Hall)

Range of ozone concentration mcg/m^3	**Mean ozone concentration mcg/m^3**	**Mean mortality in day**	**Range of ozone concentration mcg/m^3**	**Mean ozone concentration mcg/m^3**	**Mean mortality in day**
30-49	39.3	9.2 (Count=134)	50-82	62.7	9.85 (Count=97)
Increase in the mortality in day	**Stiudent criterion t**	**(α) t**	**Mean mortality in day**	**Share of the increase in the mortality of mean mortality (%)**	
0.65	1.33	0.15	9.47 (Count=231)	6.9	

Data of the Emergency Care Medical Centre of Tbilisi City Hall confirm an increase in the mortality with the increased concentrations of surface ozone also. In this case the share of the increase in the mortality of mean mortality equal 6.9 % (table 4). Subsequently in proportion to the accumulation of data these estimations will be refined.

It should be noted that under the conditions of Tbilisi city the daily maximum concentration of surface ozone 50 mcg/m^3 and above very negative influences the health of people. This concentration is considerably less (3-5 times) than accepted in Europe and USA the values of the maximum permissible concentrations of surface ozone [11].

Conclusions

Trend of the mortality in Tbilisi city in 1984-2010 has a nonlinear nature and by the fifth order power polynomial is described.

The increased of surface ozone concentrations (and its accompanying harmful for the health people the components of smog) on the average increase yearly mortality of the inhabitants of Tbilisi city by 1680 people.

Data of the Emergency Care Medical Centre of Tbilisi City Hall confirm an increase in the daily mortality with the increased concentrations of surface ozone also.

Under the conditions of Tbilisi city the concentration of surface ozone 50 mcg/m^3 and above very negative influences the health of people. This concentration is considerably less (3-5 times) than accepted in Europe and USA the values of the maximum permissible concentrations of surface ozone.

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ქ. თბილისის მოსახლეობის სიკვდილიანობის დინამიკა და მისი კავშირი მიწისპირა ოზონის კონცენტრაციასთან

ა.ამირარაშვილი, თ. ხუროძე, პ. შავიშვილი,
რ. ბერიაშვილი, ი. ირემაშვილი

რეზიუმე

მოყვანილია ქალაქ თბილისში 1984-დან 2010 წლებში 1000 მოსახლეზე სიკვდილიანობის (M) ცვალებადობის დეტალური სტატისტიკური ანალიზის შედეგები. შესწავლილია მოცემული დროითი რიგის მახასიათებლები (ავტოკორელაცია, ტრენდი, შემთხვევითი კომპონენტები და ა.შ.). კერძოდ, M-ის მნიშვნელობა იცვლება 8.03-დან 12.35-მდე, სიკვდილიანობის ტრენდი აიღწერება მეხუთე რიგის პოლინომით და ა.შ. შესწავლილია მიწისპირა ოზონის კონცენტრაციის გავლენა სიკვდილიანობაზე. ნაჩვენებია, რომ ქალაქ თბილისის პირობებში მიწისპირა ოზონის კონცენტრაცია 50 მკგ/მ^3 და ზემოთ ძალზე ნეგატიურად მოქმედებს ადამიანების ჯანმრთელობაზე და იწვევს სიკვდილიანობის ზრდას.

ДИНАМИКА СМЕРТНОСТИ НАСЕЛЕНИЯ ГОРОДА ТБИЛИСИ И ЕЕ СВЯЗЬ С КОНЦЕНТРАЦИЕЙ ПРИЗЕМНОГО ОЗОНА

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И. Иремашвили**

Резюме

Представлены результаты детального статистического анализа изменчивости смертности населения города Тбилиси на 1000 жителей (M) в 1984-2010 гг. Изучены характеристики указанного временного ряда (автокорреляция, тренд, случайные компоненты, и т.д.). В частности, значение M меняется от 8.03 до 12.35, тренд смертности описывается полиномом пятой степени и т.д. Изучено влияние содержания приземного озона на смертность. Показано, что в условиях города Тбилиси концентрация приземного озона 50 мкг/м^3 и выше очень негативно влияет на здоровье людей и приводит к росту смертности.