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ADVERSE CLIMATIC CONDITIONS AND THEIR CONSEQUENCES FOR HUMAN HEALTH

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Abstract

The overview of works on problem of environment impact on human health is presented. Consequences of summer heat of year 2003 in Western Europe, in Moscow in years 2001 and 203, on territory of European territory of Russia and in Tatarstan in July-August of 2010 are considered as example. One of the most informative bio-meteorological indexes, the index of pathogenicity, was calculated with use of data of meteorological measurements at 19 stations of Privolzhskii federal precinct (PFP) in years 1966-2010.

The major attention is paid to pace-temporal analysis of both summary index of pathogenicity and its particular constituents on territory of Privolzhskii federal precinct (PFP). Increasing of irritating weather conditions occurs from south-west of PFP to north-east. Comfortable weather conditions are characteristic for summer months. At this in winter period the major contribution in summary index I is made by indexes of pathogenicity of air temperature and day-to-day temperature variation; in summer period increases the role of pathogenicity indexes of cloud coverage and humidity. Contribution of wind speed and day-to-day pressure variation into summary index of pathogenicity is insignificant in all year's seasons. Analysis of arrangement of repetition rate of pathogenicity index showed that comfortable weather conditions (more than 50% of cases) falls on May-August, irritative – on March-April, October, and acute, more than 50% cases, happens in January, February, November and December.

Key words: climate changes. index of pathogenicity, day-to-day variation, human health, environment.

Introduction

In recent years changes of climate are considered as one of the leading factors impacting on health, along with such traditional risk factors of industrial era as pollution of atmosphere air and drinkable water, smoking, drug addiction and others [1]. By estimation of World Health organization (WHO)[2], at present time climate changes are the cause of approximately 150 thousand of untimely deaths in the world (0.3% from total number of deaths) and $55*10^6$ man-years of labor disability per year (0,4% of total labor disability).

Numerous characteristics of contemporary climate disability and also their possible consequences for natural and social-economic systems found a thorough consideration in two generalizing reports [3, 4]. Contemporary changes of a range of major climate indexes at regional levels are considered in works [5, 6].

Problems of environmental impact on human are considered in a range of works [1, 7-11], where the connection between indexes of environment condition (E) on one side and of human health on another is found. Undoubtedly, due to complex nature of happening processes, multi-factoriality of impact, it is difficult to find direct cause-consequential connection between condition of E and human health. Especially that one impacts have a direct nature, and other ones - indirect. And by their nature that can be strong and weak, fast and slow [8].

Ones of the most important "meteo-patho-lauching factors" causing pathological meteotropic reactions are day-to-day (>1.5σ of climate standard) variations of temperature, pressure, air humidity, wind speed, indexes of oxygen density, atmospheric electricity and geomagnetic activity [7]. At this optimal (comfortable) conditions for a man occur when average daily air temperature is 18°C, relative humidity 50%, no clouds, wind and day-to-day variations of air temperature and atmosphere pressure.

In estimation report of Roshydromet [4] are considered consequences of climate changes (warming) on territory of Russia that happened recently. In particular, the attention was paid at increase of repeat rate (frequency) and strength of heat waves, long-term periods (in season's limits) with extremely high temperature. In works [1, 2] is shown that a stable long-lasting hot weather causes the increase of number of deaths and cardiovascular diseases (infarct), cerebrovascular diseases (insult), diseases of breath organs and endocrine system (diabetes) etc. Events of August 2003 in Western Europe [12], consequences of heat waves in Moscow in years 2001 and 2003, and especially catastrophic consequences of heat in 2010 on territory of European part of Russia occurred due to the blocking anticyclone. According to [13], the blocking anticyclone was established over central regions of European Russia and Povolzhye in third decade of June and existed for 55 days till the middle of August, which caused a dry and very hot weather. Within all July at day the air temperature was riding above 30°C, reaching, particularly, 39.6°C in Kazan, which is the upper limit of its variations for this location. The heat sharply fall only with passing of a cyclone from west at the end of the second August decade.

According to [1], the heat-wave that continued in the first half of August, led to the most significant increase of mortality more than 1.5 times by comparison to August of 2009 on territory of a range of regions and republics, located in European part of Russia. At this the major reason of additional mortality became the disease of cardiovascular bodies (34.5 thousand from 54 thousand cases).

Analysis of medical indexes for 8 years (2008-2015) on territory of Tatarstan showed that in period of extreme heat of summer 2010 (July-August) occurred a drastic increase of mortality cases number for 2528 additionally by comparison with July-August of 2009. At this, consequences of heat in August 2010 were more fatal than in July (Table 1, Fig. 1).

Table 1: Indexes of mortality of population of the Republic of Tatarstan in summer period of years 2008-2015.

Month	Year							
	2008	2009	2010	2011	2012	2013	2014	2015
June	4373	4184	4160	3913	3775	3795	3676	4268
July	4234	3882	4527	4245	3941	3934	3911	3700
August	3847	3592	5475	3893	3738	3651	3722	3568

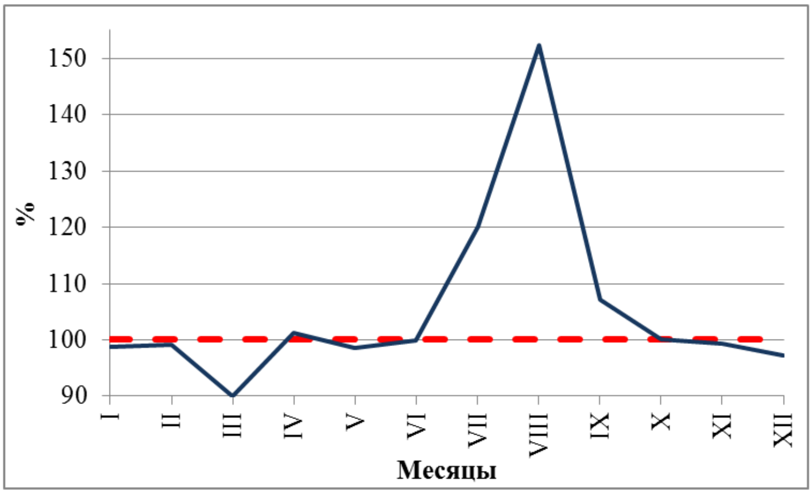

Fig. 1. Proportion (%) of monthly indexes of mortality of Tatarstan population in 2010 related to level of year 2009. (dashed line - level of 2009).

As can be seen from Fig. 1, mortality in August 2010 in comparison to August 2009 in Tatarstan increased for 52.4%. Therefore, adverse consequences of extreme summer heat of year 2010 had a direct impact on residents of Tatarstan.

Materials and methods

Standard meteorological observations at 19 stations of PFP in period of years 1966-2010 were used as initial data.

Day-to-day variations of pressure and air temperature were estimated.

In order to estimate short-term impacts of weather conditions on general state and health of a man was calculated summary meteorological index od pathogenicity I, proposed by V.G. Boksha and B.V. Bogutskiy [15]:

$$I = I_t + I_f + I_v + I_n + I_{\Delta p} + I_{\Delta t}, \quad (1)$$

where I_t is the index of pathogenicity of air temperature: I_t=0,02 *(18-t)^2 at temperature less than or equal to 18°C; I_t=0,02 (t-18)^2 at t>18°C; t – average daily temperature, $I_{\Delta t}$ – index of pathogenicity of day-to-day temperature variation Δt; I_f– index of pathogenicity of air humidity; f – average daily relative humidity (%); I_v –index of pathogenicity of wind; V – average daily wind speed (m/s); I_n – index of pathogenicity of cloud coverage determined by 11-point scale: 0 corresponds to complete absence of clouds, 10 points - complete cloud coverage, n – points of cloud coverage; $I_{\Delta p}$ – index of pathogenicity of day-to-day variation of atmosphere pressure Δp.

In practice for calculation of pathogenicity index I (points) the working formula is used:

$$I = 10^{\frac{f-70}{20}} + 0,2\,V^2 + 0,06n^2 + 0,06(\Delta p)^2 + 0,3(\Delta t)^2 + I_t. \quad (2)$$

At this by authors [15] are proposed three grades in meteorological situation pathogenicity index:

Index of pathogenicity	0-9	10-24	>24
Weather conditions	Optimal (comfortable)	Irritative	Acute

Results and their discussion

As is known, day-to-day variations of meteoparameters impact general condition of a man. Absolute values of day-to-day variation of atmosphere pressure ΔP (gPa) and air temperature Δt (°C) foe 19 stations of PFP in period of years 1966-2010 were estimated. Annually cycle of calculated parameters with maximum in January and Minimum in July, and also growth of variations of considered values in direction from south-west to north-east of precinct is observed. So, in January averaged values Δt by months for period of years 1966-2010 changes from 3.6 at south-west of precinct to 4.4 °C on north-east, in July values of day-to-day variations decrease to 1.6-1.9 °C.

Day-to-day variations of pressure are changing in January by territory of PFP at moving from south to north from 5.18 to 6.48 gPa, and in July from 2.31 to 2.89 gPa. Static analysis of day-to-day variations of meteoparameters shown that in January most frequently day-to-day variations of temperature are found in the range of 0-4.0°C (60% of cases), in July approximately in 60% of cases these variations are found in the range of 0 – 2,0 °C. A similar situation exists for atmosphere pressure too. So, in January in 60% cases ΔPdoes not exceed 6 gPa, and in July variations of ΔPin 61% of cases occur in the range of 0-2.7 gPa. Therefore, a major mass of day-to-day temperature variations has relatively low numeric value and only in 29% cases in January ΔP exceeds 8 gPa, and Δt in 14% of cases, respectively, 8℃ , which, according to [7], causes an adverse reaction of a man. In summer period these indexes are significantly smoother and large variations of ΔP and Δt are rare.

In practice, in order to estimate a degree of comfortableness of weather conditions, numerous biometeorological indexes are calculated, and for estimation of a human organism reaction for external impacts is used medical statistic of ambulance calls, morbidity and mortality of population. Researches on this theme for diverse regions of Russia are conducted in a range of works [1, 7, 14].

Estimation of complex index I and its constituents for territory of Privolzhskiy federal precincts for12 months of year by standard meteorological observations of 20 meteostations in period of years 1966-2013 (data of ARHDHI-GDC foundation) is conducted in this article. First of all, constituent components of formula (1) were calculated by average daily data, then their multi-year average monthly values for each of 20 stations of PFP were found, that allowed to estimate annual cycle and territorial differences of pathogeneric indexes (see Table 2). As can bee seen from Table 2, on all territory of precinct the annual cycle of index I is well defined: maximum I is observed in November-February which characterizes weather conditions as acute (I is more than 24 everywhere), in March, April, September and October at most of stations are formed irritative weather conditions (I varies from 10 to 24) and only in summer month at most stations, except for northern Lalsk and Nyrob, weather conditions are comfortable. Undoubtedly, this is an average climate picture that can strongly vary in separate days. Significant territorial variations in arrangement of I by precinct territory should be noted too: for major part of a year at north and north-east of PFP (Lalsk, Nyrob) irritative and acute weather conditions are formed, at south-west (Balashov) the weather conditions are comfortable from May to September. At this acute weather conditions are forming in cold period of year in conditions of active synoptic processes at fast motion of air masses and atmosphere fronts, causing significant short-tine variation of meteo-values, to law temperature background and high relative humidity [6].

Table 2: Average values of general pathogenicity index (I) by meteo-stations.

Station	Month												YEAR
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
Ulu-Telyak	43.1	36.1	22.6	14.2	11.3	9.8	9.6	11.5	14.9	19.2	29.7	41.4	21.9
Uchaly	38.2	34.6	23.3	14.9	11.2	8.0	7.7	9.2	12.0	16.9	27.6	35.2	19.9
Cheboksary	40.2	35.2	23.0	13.9	10.2	8.2	7.3	9.0	13.1	20.0	31.1	37.8	20.7
Kirov	43.3	35.7	22.4	14.6	11.8	9.3	8.3	10.7	14.6	22.7	33.2	39.7	22.2
Lalsk	48.6	40.7	26.2	16.9	13.4	11.2	10.5	13.3	17.6	24.8	36.1	44.5	25.3

Saransk	37.7	34.2	22.9	13.0	9.2	7.7	7.1	8.1	12.1	18.6	28.3	35.2	19.5
N. Novgorod	38.5	34.1	20.6	13.0	9.3	8.0	7.3	9.0	12.9	19.4	28.6	35.6	19.7
Orenburg	39.4	35.7	23.7	12.4	7.9	7.0	6.0	6.4	8.2	14.1	26.2	35.8	18.6
n.-w. Ozernyy	42.8	39.9	29.8	16.0	9.7	7.3	6.4	7.0	8.9	15.0	29.6	39.7	21.0
Nyrob	50.3	41.2	26.7	18.9	14.9	11.3	10.6	14.3	18.9	27.4	39.1	48.1	26.8
Perm	44.2	36.7	22.7	16.0	12.9	9.1	8.3	11.1	16.1	22.0	33.4	41.9	22.9
Marx	35.5	33.2	22.0	11.7	8.2	8.0	7.3	6.6	8.5	14.2	26.2	33.7	17.9
Balashov	37.4	34.8	22.9	12.1	7.1	7.0	6.2	6.1	9.5	15.9	28.6	36.7	18.7
Perelyub	38.6	35.5	23.8	12.2	7.6	6.7	5.7	5.7	8.5	14.7	26.9	36.0	18.5
Bugulma	40.2	36.7	24.2	15.3	10.8	9.1	7.7	9.5	13.1	20.3	32.1	39.3	21.5
Kazan	38.7	33.8	22.1	13.4	9.4	7.9	6.9	8.0	12.1	18.5	29.5	36.4	19.7
Izhevsk	43.5	37.3	24.0	14.8	11.8	9.5	8.3	10.3	14.6	20.9	32.5	40.6	22.4
Ulyanovsk	38.9	36.2	23.5	13.3	8.8	7.9	6.6	7.6	11.5	17.9	28.4	36.5	19.8
AVERAGE	41.1	36.2	23.7	14.3	10.3	8.5	7.7	9.1	12.6	19.0	30.4	38.6	20.9

We will conduct the analysis of particular indexes of pathogenicity by months (constituents of formula (1)) on example of 3 stations: Nyrob (north-east), Kazan (center) and Balashov (south-west), located in different physical-geographical conditions (see Table 3).

Table 3: Average valued of particular indexes of pathogenicity by stations.

Index	Month												YEAR
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
st. Nyrob													
I_t	24.1	21.0	11.3	6.0	2.4	0.6	0.4	0.8	2.5	6.3	15.2	21.5	9.4
$I_{\Delta t}$	10.3	6.6	3.2	2.9	3.6	2.6	1.9	1.7	1.7	2.1	5.6	9.8	4.3
I_f	6.7	5.1	4.3	3.0	2.6	2.6	3.6	6.1	8.0	10.7	9.6	8.2	5.9
I_n	4.6	4.2	4.0	3.9	4.0	3.8	3.6	4.3	4.5	5.2	4.9	4.9	4.3
I_v	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5
$I_{\Delta p}$	3.7	3.3	3.1	2.3	1.8	1.1	0.7	1.2	2.1	2.9	3.3	3.8	2.4
I	50.3	41.2	26.7	18.9	14.9	11.3	10.6	14.3	18.9	27.4	39.1	48.1	26.8
st. Kazan													
I_t	17.5	16.4	9.5	3.4	0.9	0.4	0.4	0.3	1.2	4.0	10.2	15.2	6.6
$I_{\Delta t}$	6.8	5.0	1.8	2.2	3.0	1.9	1.4	1.5	1.8	1.9	3.2	6.0	3.0
I_f	6.4	4.9	4.1	2.2	0.9	1.5	1.7	2.2	3.8	5.5	8.2	7.3	4.1
I_n	4.6	3.9	3.6	3.2	3.0	2.7	2.4	2.8	3.5	4.3	4.8	4.8	3.6
I_v	0.4	0.4	0.3	0.4	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.3
$I_{\Delta p}$	3.2	2.9	2.6	1.8	1.3	0.9	0.6	0.9	1.6	2.6	2.9	3.3	2.1
I	38.7	33.8	22.1	13.4	9.4	7.9	6.9	8.0	12.1	18.5	29.5	36.4	19.7
st. Balashov													

I_t	14.3	14.2	8.7	2.5	0.6	0.4	0.5	0.4	0.9	3.2	8.4	12.9	5.6
$I_{\Delta t}$	5.7	5.2	1.9	1.9	2.1	1.7	1.3	1.6	1.7	2.0	3.0	5.3	2.8
I_f	9.4	7.6	5.6	2.6	1.1	1.7	1.6	1.3	2.9	4.9	10.0	10.7	5.0
I_n	4.8	4.2	3.6	2.8	2.1	2.1	1.9	1.7	2.7	3.4	4.6	4.8	3.2
I_v	0.5	0.5	0.5	0.5	0.4	0.4	0.3	0.4	0.4	0.4	0.4	0.5	0.4
$I_{\Delta p}$	2.9	3.0	2.1	1.5	1.0	0.7	0.5	0.7	1.4	2.1	2.4	2.9	1.8
I	37.4	34.8	22.9	12.1	7.1	7.0	6.2	6.1	9.5	15.9	28.6	36.7	18.7

Ad can be seen from Table 3, in winter the major contribution into I is made by indexes of pathogenicity of air temperature (I_t)(deviation of air temperature from optimal) and $I_{\Delta t}$ by cost of large day-to-day temperature variations, and in Balashov is distinguished the pathogenicity index of humidity I_f. In summer period in Kazan and Balashov weather conditions are comfortable and value of particular indexes is insignificant. Among them the role of pathogenicity indexes of cloud coverage and humidity is growing, the contribution of wind and day-to-day variations of pressure is low. At extreme north-east of the precinct (st. Nyrob), where the natural conditions are most severe, even in July the general index equals to 10.6, at this the largest contribution in pathogenicity is made by humidity, cloud coverage and day-to-day temperature variations. Interest is represented by information about repeat rate of weather conditions by gradations of pathogenicity index (0-9, 10-24, >24). calculations were made by all stations, in Table 4 are shown averaged data for all PFP as example.

Table 4 : Arrangement of repeat rate of pathogenicity index by gradations for PFP.

Month	Gradations of values of I		
	0-9	9.1-24	>24
I	0.0	9.3	90.7
II	0.0	16.1	83.9
III	3.7	53.8	42.6
IV	32.5	53.6	13.9
V	52.1	41.6	6.3
VI	62.3	34.5	3.2
VII	67.0	30.9	2.1
VIII	57.8	38.2	4.0
IX	39.4	49.7	10.9
X	16.4	55.4	28.2
XI	1.1	32.1	66.8
XII	0.1	12.4	87.5

According to data of this table, comfort conditions prevail in period of May-August (repeat rate more than 50%), irritative - in March-April and October, acute in January, February, November and December.

Conclusions

1. Due to amplification of summer heat in 2010 happened a drastic increase of mortality cases (approximately for 53%) ion territory of Tatarstan.

2. Within a year on territory of PFP the summary index of pathogenicity changes from values of 35.5 - 50.3 (January) to 5.7 - 14.3 (July). The most severe climate conditions are forming at north-east.

3. The most significant contribution in summary index is made by constituents depending on deviation of air temperature from optimal. day-to-day variations of temperature, humidity and cloud coverage.

4. Average comfortable weather conditions by precinct prevail in period May - August (more than 50% of cases), irritative - in October, March-April and acute in November-February.

Summary

Results presented in article give the evidence of the fact that risks for a human health are necessary to take into account, especially in extreme meteorological conditions. Authors continue researches in this direction with involving of other biometeorological indexes in order to estimate the degree of comfortableness of residential conditions of population on territory of PFP.

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