

Urban development of heat island territories and the health of the northern indigenous population

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Abstract. The paper considers the issues of urban development and climatic conditions of Sumburgh municipal entity of Purovsky district located in Yamalo-Nenets Autonomous Okrug. The authors have carried out the correlation analysis of the climatic conditions in the environment of the region and the health status of the Nenets people living in the cold desert (tundra).

1 Introduction

Temperature in the urban environment was different from the surrounding area. Due to the dense construction, zones of less mobile air appear in them, and heat and moisture of anthropogenic origin, etc., enter the atmosphere [1, 2]. This contributes to the formation of "urban heat island", in which the air temperature, depending on the infrastructure, can increase from 1-2 ° C to 6-7 ° C [3, 4, 5]. Accommodation conditions and health of people depend on the climatic characteristics of the territories, this is especially typical for the northern areas [6]. The Far North is characterized mainly by the cold climate [7]. Harsh climatic conditions are expressed in low ambient temperatures, originality of geomagnetic background, light regime, solar radiation deficiency [8].

Therefore, it is important to consider the impact of climatic characteristics on human health [6, 7, 9, 10]. For example, traditional forms of activity of the indigenous peoples of the North is an important basis for their livelihood, and at the same time, the traditional nature management of these people is a key element of the northern ecosystems [11, 12] and is largely determined by their natural and climatic characteristics [13].

2 Materials and methods

The long established stable population of tundra Nenets [14], who inhabits in the municipal entity of the Sumburgh of Purovsky district of Yamalo-Nenets Autonomous District (YaNAO), was chosen from the total array population of Arctic as the object of study. Sumburgh is divided into functional and territorial zones. The type of buildings is brick.

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Buildings - one- and two-storey. In the industrial zone there are a boiler house, transformer substations, a fire station, etc. There is a network of water pipelines, a sewage and heat network, asphalt and concrete pavements.

The following features of the Sumburgh are considered to study the climatic conditions of urban settlements: the average annual temperature, the average temperature in the 1 p.m., the average minimum and maximum temperature, wind speed, the number of days with strong winds, characteristic of the wind rose and the calms during the year, relative humidity, the number of days with relative humidity at 1 p.m. $\geq 80\%$ and $\leq 30\%$, the amount of precipitation during the year, the highest daily precipitation, highest decadal snow cover depth. Climatic data for particular years were obtained from the USSR climatological handbooks [15-18] and www.meteo.infospace.ru site for 1988 – 2006 [19].

Immune health status of Nenets of tundra evaluated during the expeditions of 1999 - 2002 years. Blood sampling was carried out to study the immune status. Test group signed up a consent form and study plans that have been approved by the Commission on Ethics on the basis of the Federal law under Articles 18, 20, 21, 22, 28 and 41 of Constitution of Russian Federation and Articles 18-22 of 21.11.2003, № 323 "About the basis protection of health of citizens of the Russian Federation". Methods of fluorescence microscopy and immunohistochemistry (CD-95, CD-3) used for the identification of different populations and subpopulations of immunocompetent cells and their functional activity. The concentration of serum immunoglobulins IgA, IgM was determined by ELISA using a kit "Vector-Best" reagents, Novosibirsk. Determination of interleukin-4 (IL-4) was carried out by solid phase ELISA using a kit of reagents «Pr Con IFgamma» produced by "Protein contour", St. Petersburg.

Qualitative and quantitative traits were statistically processed using an integrated software package «SPSS 11,5 for Windows». The following statistical parameters: the average value (arithmetic mean, median and mode), dispersion and its derivative (average quadratic deviation) are used in a normal distribution. There were made comparisons of the significance of differences or similarities between the statistical characteristics obtained in the study compared samples (Student's criterion). Standard error of the arithmetic mean value was calculated to finding the significance of differences between average values. Non-parametric methods of comparing two samples with the calculation of the pair Wilcoxon's criterion, Spearman rank correlation coefficient are used in the absence of normal distribution.

3 Climatic conditions of the municipal entity of the Sumburgh of Purovsky district of Yamalo-Nenets Autonomous District and the health of the Nenets of tundra

It is known that the development of urban areas is affected by natural climatic conditions (Table 1). It was found that in the considered region the average temperature is -7.05 ± 1.40 °C, the average wind speed is 7.06 ± 0.35 m/s. The number of cases of the wind of various directions considered into different times of the day, according to [16]. During the year, southern and south-westerly winds are mainly dominated. Average rainfall for a year makes 349.92 ± 16.88 mm. The highest decadal snow depth during the winter is 54.50 ± 4.01 cm.

Climatic characteristics of urban heat island largely determine the health status of the population. So, in the municipal entity of the Sumburgh of Purovsky district of YaNAO, the immune pathology in the form of secondary immune deficiency (SID) [20, 21]

constitute 33.50 ± 1.66 %. It is known that the health is provided by morphofunctional state of the immune system [22-24].

Table 1. Climatic characteristics of Sumburgh (average value).

	Parameter	Value
1.	Temperature characteristics	
1.1	The average annual temperature, [°C]	-7.05 ± 1.40
1.2	The average temperature in the 1 p.m., [°C]	-7.03 ± 0.44
1.3	The average minimum air temperature, [°C]	-12.75 ± 0.37
1.4	The maximum air temperature, [°C]	26.57 ± 0.30
2.	Wind	
2.1	The wind speed, [m/s]	7.06 ± 0.35
2.2	The number of days with strong wind	51.55 ± 7.24
2.3	The wind direction during the year, [the number of cases]:	
2.3.1	North	165.64 ± 7.51
2.3.2	North-East	97.82 ± 7.23
2.3.3	East	76.45 ± 9.91
2.3.4	South-East	173.91 ± 9.40
2.3.5	South	221.82 ± 8.97
2.3.6	South-West	209.18 ± 10.31
2.3.7	West	177.09 ± 7.60
2.3.8	North-West	189.64 ± 8.55
3.	Air humidity	
3.1	Relative humidity at different times of the day, [%]	
3.1.1	1 a.m.	85.14 ± 0.99
3.1.2	7 a.m.	84.38 ± 0.89
3.1.3	1 p.m.	78.38 ± 1.07
3.1.4	7 p.m.	81.13 ± 1.01
3.2	The number of days with relative humidity at 1 p.m ≥ 80 %	175.43 ± 13.17
3.3	The number of days with relative humidity at 1 p.m ≤ 30 %	0.57 ± 0.30
4.	Precipitation	
4.1	The amount of precipitation during the year, [mm]	349.92 ± 16.88
4.2	The highest daily amount of precipitation, [mm]	28.00 ± 4.70
4.3	The highest decadal snow depth during winter, [cm]	54.50 ± 4.01

Characteristics of the immune system tundra Nenets are presented in Table 2. The correlation analysis of immunological parameters with climatic indicators in the Sumburgh was conducted. The average daily temperature, relative humidity of the air, wind speed, precipitation was estimated a week before blood sampling of tundra Nenets. In our opinion, the content of leukocytes in the blood of practically healthy people is associated with the number and variation of precipitation ($r = 0.462$ for $p < 0.05$ and $r = 0.537$ for $p < 0.05$

respectively), with the wind speed ($r = -0.513$; $p < 0.05$). In the group of people with SID blood, the content of leukocytes depends on variations in precipitation ($r = -0.517$; $p < 0.05$), air temperature ($r = -0.528$; $p < 0.05$).

Content of basophils in blood depends on the climatic characteristics. The increase basophils in blood caused by an increase in relative humidity ($r = 0.718$; $p < 0.05$) and air temperature ($r = 0.670$; $p < 0.05$) for healthy tundra Nenets. The population with the SID number and variation of precipitation ($r = 0.893$ for $p < 0.001$ and $r = 0.885$ for $p < 0.001$ respectively) and relative humidity ($r = 0.899$; $p < 0.001$) is also associated with changes content of basophils in blood.

Table 2. Characteristic of the immune system.

Parameter	Value
Leukocytes, [ths./mm ³]	7.01 ± 0.19
Eosinophils, [%]	2.39 ± 0.31
Basophils, [%]	0.13 ± 0.05
Banded neutrophils, [%]	1.98 ± 0.95
Segmented neutrophils, [%]	47.63 ± 1.07
Monocytes, [%]	6.24 ± 0.26
Lymphocytes, [%]	43.43 ± 1.03
IgA, [g/l]	2.05 ± 0.05
IgM, [g/l]	1.56 ± 0.03
CD3+ lymphocytes, [%]	51.91 ± 1.04
CD95+ neutrophils, [%]	1.39 ± 0.20
IL - 4, [pg/ml]	56.87 ± 11.91

The level of segmented neutrophils in the group of healthy individuals depended on the number and variation of precipitation ($r = 0.703$ for $p < 0.05$ and $r = 0.656$ for $p < 0.05$ respectively). With SID increase of number of variation and precipitation ($r = 0.703$ for $p < 0.05$ and $r = 0.656$ for $p < 0.05$ respectively), increase and variation of air temperature ($r = 0.642$ for $p < 0.05$ and $r = 0.715$ $p < 0.05$ respectively), decrease in wind speed ($r = -0.895$; $p < 0.001$) is associated with an increase in the number of segmented neutrophils in the blood. With the increase in air temperature in a healthy population content CD95+ neutrophils ($r = -0.659$; $p < 0.05$) decreases. In contrast to the healthy population, people with SID with increasing variations in precipitation and relative humidity levels of CD95+ neutrophils ($r = 0.784$ for $p < 0.01$ and $r = 0.765$ for $p < 0.01$ respectively) increased.

The increase in air temperature decreases the content of monocytes in blood in healthy population ($r = -0.688$; $p < 0.05$). With regard to content in blood lymphocytes, their levels in the blood decreased with the increase of precipitation in a healthy population ($r = -0.671$; $p < 0.05$) and wind speed variations for people with SID ($r = -0.807$; $p < 0.01$). And the content in the blood CD3+ lymphocytes for people with SID - by the wind speed ($r = -0.610$; $p < 0.01$).

When analyzing the humoral immune system there were installed the following correlation dependence on climatic characteristics of the municipal entity of the Sumburgh of Purovsky district of YaNAO. The increase in the number and variation of precipitation is accompanied by increasing IgA content in a healthy population ($r = 0.498$ for $p < 0.05$ and $r = 0.936$ for $p < 0.001$ respectively) and decrease of it for people with SID ($r = -0.521$; $p < 0.05$). It is also found that with the decrease of the air temperature level of content of IgA in blood serum of the healthy population ($r = 0.594$; $p < 0.05$) decreases. However, this

parameter increased for people with SID ($r = -0.507$; $p < 0.05$). It was revealed that for people with SID increase of wind speed is also accompanied by increasing IgA content in blood serum ($r = 0.551$; $p < 0.05$). An increase in amount of precipitation is associated with increasing IgM in blood serum ($r = 0.600$ for $p < 0.05$ and $r = 0.480$ for $p < 0.05$ respectively) for the healthy population as well as for people with SID. Also with the increase of the air temperature the content of IgM in blood serum ($r = 0.576$; $p < 0.01$) increases for people with SID.

It is known that one of the repertoire cytokines of T-lymphocytes, which determines the humoral orientation of the immune system, is the IL-4 [20, 22]. It was found that its content in the peripheral blood depends on the wind speed in a healthy population ($r = -0.66$; $p < 0.05$) and for people with SID this parameter depends on average daily temperature and its variation ($r = 0.69$ for $p < 0.05$ and $r = -0.72$ for $p < 0.05$ respectively), relative humidity ($r = -0.69$; $p < 0.05$).

Our research will be continued in this direction.

4 Conclusions and suggestions

Northern areas – are the territories of great interest, in the first place, in terms of the native habitats and traditional nature management of Indigenous Peoples of the North. Therefore, when determining local standards for the urban planning of urban settlements, it is necessary to take into account natural climatic conditions. It is found that immune health indicators tundra Nenetses conjugate with temperature, humidity, velocity of air movement in urban heat island.

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