

Geoecological Assessment and Quality Protection of Natural-Anthropogenic Geosystems in Karachay-Cherkessia

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Abstract – Against the background of comparing the scope of anthropogenic impact on environmental with the scope of natural processes influencing it, it becomes obvious that humanity cannot continue to pollute the environment uncontrollably, however, it cannot stop or at least reduce the rate of economic activity. From this standpoint, the analysis of influencing factors and response forms of geosystems, where the tendency to reduce the quality of life-supporting conditions, the level of public health, and the nature of unbalanced nature management is kept, is of particular relevance. Climatic parameters dynamics analysis, air pollution conditions and characteristics, deterioration of medical and environmental indicators with response of the health status of the population according to the classes of morbidity and transformation of forest communities increase the need to implement a system of integrated environmental and geographical monitoring and allow to form databases as well as to justify measures to improve environmental management and geoecological well-being of the region.

Keywords – *natural anthropogenic geosystems; ecological monitoring; geography-specific climat; warming; surface atmosphere; pollution; health classes; forest stand transformation.*

I. INTRODUCTION

North Caucasus 21st century geopolitical events including the ones on the territory of the Karachay-Cherkess Republic have led to the medical-geographical situation worsening and aggravation of the geo-ecological situation on the mentioned territory. The introduction of market relations in the republic, the destruction of socio-economic relations have led to a sharp decline in production and, consequently, a significant drop in the requirements for the population health promotion. It has led to the need to study the impact of changing environmental factors and man-made pressure on the population health

indicators, determine the cause-effect relationships that would form a set of measures to preserve the geo-ecological balance.

Mountain forests are sensitive to the introduction of polluted air and to the influence of other factors, especially weather (wind, snow, frost) and harmful insects (moth larvae, spruce bugs, bark beetles). These processes correct serai processes and change forest structure.

Many facts of mountain forests deterioration caused by atmospheric pollution resulting in acid precipitation, as well as heavy metals and phytooxidants precipitating have been recorded. Due to the fact that there is more precipitation in the mountains, these areas are more vulnerable to chemicals and suspended substances of the atmosphere.

The purpose of geoecological monitoring of Karachay-Cherkessia is to study the impact of a complex of environmental factors and man-made load on natural geosystems and population health indicators and to define cause-effect relationships between them as well as the development of geo-environmental recommendations and measures to improve environment quality and public health.

Tasks:

- observation and control over the state of life-supporting habitat and public health according to uniform methodology and programs for information collecting, processing and disseminating;
- establishment of causal relationships between the indicators of public health and environment, analysis as well as assessment of ongoing changes in the state of population health under the influence of adverse factors of the natural-anthropogenic environment, justification of the identified dependencies;

- ensuring the population health and well-being; determining priority directions in social and environmental policies aimed at protecting health and preventing diseases, improving the quality of the living environment and living conditions of people.

Hypothesis. According to Roshydromet, the level of air pollution in 138 cities of the Russian Federation (which makes 57% of the urban population) is characterized as high and very high. The level of air pollution in 33 regions of the Russian Federation is either high or very high (notably the observations were carried out only in 1-3 cities). A high and very high level of urban air pollution was not observed only in 9 regions of the Russian Federation. Karachay-Cherkessia is among such subjects. Nevertheless, a significant increase in air pollution is already observed in Karachay-Cherkessia.

The system of geo-environmental monitoring carried out by the research laboratory of Karachay-Cherkess State University named after U.D. Aliyev and other bodies of Karachay-Cherkessia exercising supervision over the state of the geosystems dynamics, the quality of their natural-climatic sanitary-hygienic and anthropogenic parameters acknowledges the changes not only in natural landscapes but also in the state of public health in unity with the ecosystem. At the same time, the main monitoring requirement is that forecast is implemented on the basis of identifying trends in environmental factors, dynamics of landscape and population health status according to the morbidity classes.

Recently, a very significant eastern spruce (*Picea orientalis*) drying out was stated in the natural forests of the Teberdinsky Reserve. Drying out is noted both in individuals and in communities and geosystems. Particularly pronounced nature of the drying out spruce spread is noted on the slopes of the upper Teberda River and in the gorges of the rivers Amanauz and Gonachkhir, which form the river Teberda at the confluence [1]. The results of chemical analysis of air and spruce needles indicate technogenic pollution of the atmospheric air in the recreation area.

Preservation of biodiversity in genetics is very promising at the level of species and populations. It is considered that a high degree of genetic variability contributes to plants adaptation to the conditions of a polluted environment and more heterozygous individuals also possess greater vitality in technogenic biotopes [2]. The probable possibility of distinction is peculiar to age populations.

In this connection, the problems of studying and identifying the links of the impact of a changing environment with quantitative and qualitative geosystems indicators and the health of the population of the region become topical.

II. METHODS AND MATERIALS

The systems of sanitary and hygienic monitoring are implemented at the regional level by the so-called Geocological Monitoring blocks. First of all, adverse environmental factors (surface water, atmospheric air, industrial and household waste) and the response of biota including the human body are analyzed according to the data on spatial-temporal morbidity rates of the population [3].

A modern analysis of regional climate indicators is made on the basis of the extensive material of the Hydrometeorological Service of the Southern Federal District, nature records of the Teberdinsky State Natural Biosphere Reserve, sources of the Ministry of Natural Resources of Karachay-Cherkessia on climate and geographical landscape components (topography, geology, soils, etc.) as well as on data obtained by stationary and expedition methods.

The methodology of geocological research consisted in the formation of air quality monitoring database grounded on the analysis of samples from observation posts, which is conducted by Rostekhnadzor in Karachay-Cherkessia, the Center for Laboratory Analysis and Technical Measurements in Karachay-Cherkessia and the Scientific Research Laboratory of Geocological Monitoring of KCGU (Karachay-Cherkess State University named after U.D. Aliyev). Observations were made at additional points for the collecting single samples during sanitary and hygienic monitoring.

The air quality monitoring network in Karachay-Cherkessia includes 7 monitoring stations. Concentrations from 5 to 25 substances (atmospheric air impurities) are measured in most on-site stations. Stationary points are located in residential areas, near highways and large industrial facilities. The stations are divided into urban backgrounds (in residential areas), industrial, auto (near major highways) and local ones in accordance with their position. Observations are carried out in the tourist and recreational areas of the republic in addition to the stations of a single stationary system.

The quality of the atmospheric air of populated areas is monitored by Rospotrebnadzor in accordance with GOST 17.2.3.07-86 "Rules for the control of air of populated areas". Four observation programs are used for observational stations depending on the source of pollution and harmful substances concentration.

The list of pollutants subject to control is determined on the basis of information concerning the composition and nature of emissions from pollution sources in a region and meteorological conditions of dispersion of impurities in accordance with RD 52.04.186-86 "Guidelines for Control of Atmospheric Pollution" and GOST 17.2.3.01-86.

Among the various methods of geo-ecology and sanitary-hygienic monitoring, the most relevant are the methods of geo-information analysis and research based on combined ground-aerospace environmental monitoring. Traditional ground-based observation and measurement tools are successfully complemented by aero-satellite imagery due to their scale and high information content.

Industrial enterprises create zones of technogenic impact of various technogenesis. They elicit response from the population by transforming the environment. Numerous studies have proven the long-term benefits of the method of applied measurement of the fields of anthropogenic impact based on the interpretation of aero-satellite images [4]. Such remote operational monitoring of the geocological environment state is most suitable for vast and largely differentiated mountainous areas, where it is extremely difficult to conduct ground-based measurements.

III. RESULTS

The entire territory of Karachay-Cherkessia was allocated as a model for solving this problem in accordance with the set objectives. The republic is located on the northern slope of the Western Caucasus. The relief of the territory is very diverse, the differences in elevations range from 400 m above sea level in the plain-hilly part to 5,642 m on the top of Elbrus in the high mountain region. The territory of the republic is conventionally divided into following landscape sub-regions basing on the natural-geographical point of view and according to the characteristics of vertical zonality:

I sub-region is submontane (plain-hilly terrain) 400 to 700 m above sea level. This zone includes Adyge-Khablsky, Nogai districts and the city of Cherkessk.

II sub-region is submontane (low-hill terrain) of 700 to 1,500 m above sea level. This zone includes Prikubansky, Khabezsky and Abaza districts.

III sub-region is mid-mountain 1,300 to 2,500 m above sea level. This zone includes Ust-Dzhegutinsky, Urupsky and Malokarachayevsky districts. Separate peaks of this zone are above 3,000 m high.

IV sub-region is highland 1,600 m above sea level. The average height here is from 3,000 to 4,000 m above sea level. Conventionally, this zone includes the territories of Karachay and Zelenchuksky districts and the city of Karachayevsk.

The subdivision of the republic territory into landscape sub-regions is caused not only by a significant difference in elevation but also by distinctive parameters, climatic conditions, degree of anthropogenic load, assimilation potential of geosystems, their self-cleaning ability. This certainly affects the environment, biodiversity, and population health and requires system monitoring their interconnection and interdependence.

Content and activity of air pollutants affect human health increase with the rise in temperature and environment humidity [5]. Increase of the humidity reduces the assimilative capacity of geosystems and enhances the pathogenic effect of pollutants, their transformation in the natural environment [6]. Recently, there have been more frequent cases of inversions, fogs, frost and even smog on the territory of Karachay-Cherkessia, which indicates an increase in air pollution with aerosols in particular. Acid rains precipitation reflects the presence of acidic compounds condensing in the clouds in the atmospheric air and falling as precipitation. Atmospheric pollution reduces the healthy role of ultraviolet radiation and sunshine intensity. Concentration of many sources of harmful elements and compounds in the atmosphere of urbanized areas affects not only nature, but also human health, life, reduces body resistance, increases the number of so-called "diseases of civilization" (cardiovascular, nervous, respiratory, cancer) [7].

Characteristics of climate in Karachay-Cherkessia. Karachay-Cherkessia is located in the temperate zone of 43 to 44° of north latitude. It is characterized by significant differences in elevation, distribution of vegetation, extensive hydrographic network, geomorphological and geological structure of the territory which determine the climatic

conditions. The average annual temperature is 6.6°C. In the mountain-high-mountain sub-region of the republic, the average annual temperature drops to 3.5°C to the forest upper boundary. It reaches negative values at the upper limit of the forest (2,600 m) and decreases from -0.8°C to -9.5°C as it rises. The average temperature on the plain in January being the coldest month is -2.9°C in the mountain forest belt. It decreases to -5.5°C above the forest border and its values drop to -9.5°C in the highlands. The average temperature of the hottest month varies from 12.7°C in the forest belt to 21.1°C in the plain-hilly sub-region. In recent years, significant changes have occurred in the temperature regime on the territory of Karachay-Cherkessia (Table 1).

Climate modeling in Karachay-Cherkessia territory indicates its warming [8]. The temperature over the 45-year period has increased by 1.7°C and the increase in precipitation was 33.9 mm per year. The average temperature out of the absolute maximum ones increased by 2.6°C and the absolute minimum one increased by 0.9°C. All seasonal years were characterized by a rise in average values of air temperature. The heat supply in the region reaches its highest values in winter and summer-autumn months. Spring and autumn are characterized by increased precipitation.

TABLE I. CHARACTERISTICS OF CLIMATE CHANGE IN KARACHAY-CHERKESSIA FOR 1972-2016

Climatic indexes	Climatic characteristics of natural and geographical zones of Karachay-Cherkessia				
	<i>plain-hilly</i>	<i>low mountain</i>	<i>middle mountain</i>	<i>high mountain</i>	<i>region average</i>
Average annual air temperature, °C	+1.9	+1.3	+1.8	+1.7	+1.6
Average maximum air temperature, °C	+2.7	+3.0	+2.6	+1.7	+2.5
Average minimum air temperature, °C	+1.6	+0.8	+1.6	+1.6	+1.4
Average air temperature in winter, °C	+2.0	+2.3	+1.8	+2.0	+2.0
Average air temperature in spring, °C	+1.5	+2.3	+1.8	+1.7	+1.8
Average air temperature in summer, °C	+2.0	+1.9	+2.4	+1.9	+2.0
Average air temperature in autumn, °C	+1.5	+1.2	+1.2	+1.3	+0.2
Precipitation, mm/year	+32.8	+53.5	101.2	-13.2	+43.8

Climate warming in Karachay-Cherkessia has characteristic regional features and is manifested in all natural and geographical zones of the republic.

The ratio of increases in average annual air temperature in successively changing natural-geographical sub-regions (plain-hilly – submontane – middle-mountain – mountain-high-mountain) vertical zonality of Karachay-Cherkessia can be represented as: 1.5: 1: 1.4: 1.3. The ratio of precipitation is as follows: 1: 1.6: 3.1: - 0.8. Decrease in precipitation in the mountainous highland zone went beyond the general trends noted in the other natural sub-regions of altitudinal belt differentiation. The increase in annual precipitation in the republic as a whole was 43.8 mm/year.

The diversity of climate warming character in natural geographic zones is primarily due to the complexity of the orographic conditions of the mountainous terrain, redistribution of solar radiation, air currents, etc.

It is important to note that the highest air temperatures are observed on the territory of the plain-hilly terrain and low ones are inherent to the mountain-high-mountain terrain. At the same time, the minimum temperature in all sub-regions of the republic is on January, and the maximum one is observed in July in the plain-hilly and submontane sub-regions, while mountain-high-mountain terrain is characterized by the maximum temperature in August. Change in temperature with increasing altitude of the terrain creates conditions for inversion processes, when there is a concentration of air pollutants. This increases a negative impact on public health. Such inversions are most often created during the cold season or during cold snaps, especially in the resort and recreational zones of the middle-mountains, specifically, Teberda, Arkhyz, Dombay.

With regards to the plain-hilly sub-region of the republic, the average long-term temperature is 9.3°C, 7.5°C in the submontane terrain, 6.0°C in the middle mountains and 3.5°C in the mountain-high mountain terrain depending on natural and geographical factors (openness of areas, orientation on exposures, intersection of relief, etc.). It serves as the evidence that changes in temperature mainly occur in the plain area and, partly, in the submontane terrain under the conditions of stable temperature in mountain regions.

Thus, the duration of the period with positive temperatures decreases from 267 days in the plain-hilly sub-region (525 m), to 184 days in the middle mountains and to 87 in the mountain-high-mountainous territory (2,583 m). The number of days with air temperature over 10°C decreases and makes 182 days in a plain-hilly territory, whereas in the mountain-high-mountain sub-region it is no more than 3 months (92 days). In contrast, the vegetation period is reduced from plain-hilly territory to mountainous and highland terrains. Under favorable weather conditions in the mountain-high mountain terrain, the difference reaches from 15 to 17 days.

Local mountain-valley winds are predominant, in the upper part of the sub-region. In the middle-mountain and mountain-high-mountain zones the direction of the wind is determined mainly by the general orientation of the mountain ranges and valleys. Westerly winds prevail at high altitudes caused by the

western transport predominant in the middle troposphere. Western winds can be up to 80% here.

The conditions of concentration and distribution of pollutants in the atmosphere are significantly determined by winds direction. South and south-westerly winds prevail on the territory of Karachay-Cherkessia. The location of cities and settlements in the mountain gorges and valleys corrects the direction of the prevailing winds. The prevailing winds in the plain-hilly and submontane parts differ significantly from the mid-mountain and mountain-high-mountain sub-regions.

On average the relative humidity on the territory of the mountain-high-mountain sub-region reaches 76-80% per year, which is associated with a large amount of precipitation (up to 2,500-3,000 mm/year at an altitude of 3,500 m, and less than 2,000 mm/year at an altitude below 2,000 m). The relative humidity on the territory of the middle mountains is much less (70-74%) as well as in the plain-hilly and submontane territory (65-70%).

Differential elevations of the Karachay-Cherkessia territory, temperature and humidity regimes, wind distribution and its speed form the features of natural and climatic conditions having significant differences in the plain-hilly, submontane, middle-mountain and mountain-high mountain sub-regions. Climatic conditions are largely determined by vegetation and woodlands. The total forest area covering the territory of the republic is 34.2% including the protective forests.

Air pollution. According to the Sanitary and Epidemiological Inspection, total emissions of pollutants (comprising all sources of pollution) into the air in Karachay-Cherkessia on average for 2011-2015 amounted to 58.1 thousand tons. The annual amount of emissions into the atmosphere over five years varies from 50.6 to 65.2 thousand tons per year. Cherkessk experiences 52.8% of the total emissions.

The sources are usually local, especially in the mountain valleys of Kuban, Teberd, Bolshoi Zelenchuk, Urup and Bolshaya Laba. The mentioned regions are characterized by frequent cases of inversions of hydrothermal indicators, fogs, smog, frost, etc., which reduce atmospheric pollutants dispersion. The sources can also be located abroad (the Main Caucasus Ridge) or in neighboring areas of the region. Many of these pollutants in the atmosphere are durable and spread to the gills by wind currents. The adverse effects of pollutants on mountainous areas transported over long distances by air across state and administrative borders are becoming an important subject of research. Air samples were taken at the control points for the determination of nitrogen dioxide, carbon monoxide, ammonia, sulfur dioxide, phenol, formaldehyde and suspended solids in accordance with GOST 17.2.3.01-86.

Nitrogen dioxide can lead to significant changes in the human body even in case of being in relatively small concentrations in the air. It is a powerful irritant, and is also characterized by a general toxic effect. It mainly affects the organs of respiratory system. The degree of its concentrations results in various effects from mild irritation of the mucous membranes of eyes and nose to pulmonary edema. It can also

lead to changes in blood composition, in particular, helps to reduce the hemoglobin content [9, 10].

Sulfur dioxide in the atmosphere causes chronic diseases of the upper respiratory tract, certain skin diseases, breast pang.

Increased iron content in the air is one of the causes of urolithiasis and the presence of copper contributes to obesity and pathologies of musculoskeletal system.

The air near residential areas characterized by a rather high concentration of industrial enterprises and heating systems that burn solid fuel together with automobile exhaust is saturated with harmful particles, which being constantly inhaled contribute to excessive blood thickening. This, in turn, leads to thrombosis in blood vessels and significantly enhances the development of hypertension [11].

The main air pollutants in the republic are motor transport and industry. According to observations, 196 types of pollutants have been identified in the composition and structure of emissions over the past 5 years.

Over the past decade there is a tendency throughout the entire territory to the increase of carbon monoxide concentration in atmospheric air. Sources of pollutants are car exhaust fumes, coal and petroleum products burned in heat boilers, industrial submontane boilers, emissions from manufacturing plants, coal, wood or petroleum products used for household heating, and agricultural waste burning.

The number of motor vehicles including large-sized ones, on the Karachay-Cherkessia roads has increased by roughly more than 5 times since the year 2000.

An assessment of the degree of atmospheric air pollution was made by complex indicators and revealed exceedances of the following components:

- ammonia and formaldehyde in Ust-Dzhegutinsky district by 1.1 MAC and 1.3 MAC respectively;
- ammonia in Prikubansky district by 1.2 MAC;
- formaldehyde in the Malokarachayevsky district by 1.1 MAC
- increase in carbon dioxide, nitrogen and sulfur oxides in the air is steadily approaching the maximum permissible standards.

The complex air pollution index in the republic reached its maximum values in the Ust-Dzhegutinsky district and is characterized as an elevated one. The level of the complex air pollution index is relatively low in all other regions of the republic. Ust-Dzhegutinsky district with the concentration of the main enterprises manufacturing building materials (mainly cement) is the greatest total emissions polluter. Consequently, this is the area where initial measures are required to improve the sanitary and epidemiological state of the air environment.

We have calculated morbidity individual indicators reflecting the prevalence proportion, which is determined by the ratio of the number of diseases per year multiplied by 1,000 and referred to the average population of the republic. This indicator is a collective reference to negative indicators of the republic population health condition. Health statistics considers there indicators to be the criteria for health status. Respiratory organs are more susceptible to diseases practically in all regions of the republic and the second position is occupied by diseases associated with a circulatory system (Fig. 1). These types of diseases are caused by aerial environment, whose saturation with the above pollutants in Karachay-Cherkessia correlates with an increased morbidity of organs and systems.

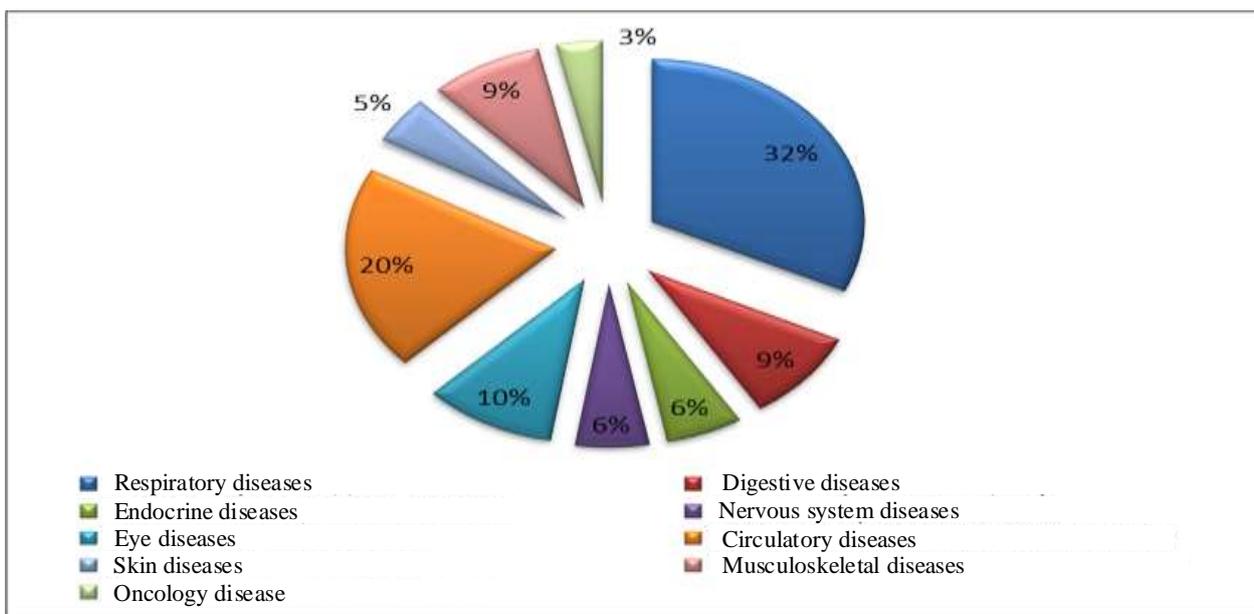


Fig. 1. Disease incidence in Karachay-Cherkessia population

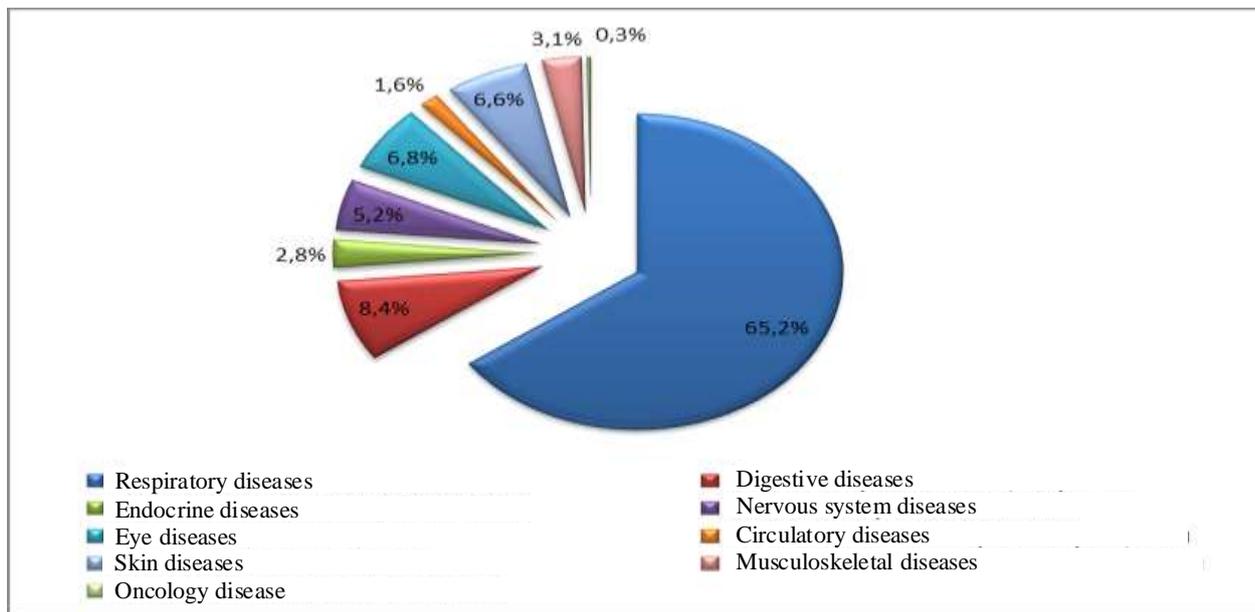


Fig. 2. Disease incidence in Karachay-Cherkessia children's population

Respiratory diseases in the population of Karachay-Cherkessia are unevenly distributed among districts. The greatest severity of these diseases is recorded in the city of Karachayevsk, Abaza, Prikubansky, Cherkessk and Zelenchuksky regions. An increased content of oxides, carbon and ammonia in the air of these areas increases the incidence of catarrh of the upper respiratory tract, conjunctivitis, and decreases resistance to infectious diseases. Respiratory organs are to a lesser vulnerable to diseases in Nogai and, quite unexpectedly, in Ust-Dzhegutinsky districts. Cement production facilities are located in the Ust-Dzhegutinsky district but diseases caused by pollutants emitted from dust predominate in Karachayevsk, Cherkessk, Prikubansky and Abaza districts. The incidence of respiratory diseases dominates especially among the children's population of the republic (Fig. 2).

The highest level of respiratory diseases in children is observed in the Nogai, Abaza and Adyge-Khabl districts, which are located in the wind rose zone of the region's industrial areas. The high incidence rate of respiratory organs in the child population of the republic has determined the leading role of these particular diseases in the structure of the criteria indicating the state of health of the entire population of Karachay-Cherkessia.

Diseases associated with the digestive organs dominate among the adult population. Respiratory diseases are the second with regards to organs incidence. Eye and circulatory diseases are on the third position in terms of morbidity.

Incidence of other organs, systems and parts of the body among the population of the republic depends on a number of reasons, a significant role among which is played by the quality of drinking water.

Incidence rates in the years 1994-1999 significantly differ from those obtained by us for the period from 2012 to 2016. The period of more than 15 years is characterized by the increased amount of gross emission of pollutants into the atmosphere of Karachay-Cherkessia over a full-year cycle. Consequently, overall morbidity among the population of the republic has increased significantly.

The incidence of respiratory organs increased by 1.4 times and the nervous system incidence rose by 1.8 times. The rates of disease of other morbidity classes increased significantly and correlation with environmental factors is very high as well. The calculated characteristics of Karachay-Cherkessia show that the class "general morbidity" correlates with emissions of dust into the atmosphere ($r = 0.80$). Respiratory diseases correlate with gross emissions of hydrogen sulfide into the atmosphere (0.77). Diseases of the nervous system and sensory organs correlate with gross soot emissions (0.81). Injuries and poisonings correlate with gross emissions of carbon monoxide (0.65), ethanol (0.89), etc.

The results of our research showed that ranking of territorial zones concerning the most unfavorable ones in terms of pollution changed in 2015. The foothills remained the leaders of pollution. However, the pollution of the mountain-high mountain (mountain) zone, which includes Karachay, Zelenchuksky districts and the city of Karachayevsk, significantly exceeded the middle-mountainous districts of the republic.

Mountain areas in general take a large amount of precipitation unlike other forms of relief, and, thus, experience heavy loads of any chemicals and particles from atmospheric moisture.

Acidity of precipitation containing elemental sulfur, nitric oxide, ammonia and heavy metals has increased in some

valleys. In addition, in the region where mountains are enveloped with clouds that linger in the crowns of trees, this additional thick fog consisting of polluting metals enhances their impact. Ozone is becoming an important component.

The analysis showed that prevalence of all diseases in the foothills is largely determined by weather conditions as well as by dust concentration of the territory. Other factors such as copper and zinc content in soil and water also exist. The prevalence of diseases of the nervous system and sensory organs in the middle mountain terrain and the mountain-high mountain one is largely determined by air pollution with ammonia and sulfur dioxide. Air pollution is very significant in respiratory diseases (especially of the child population) incidence in submontane and middle mountain areas due to harmful emissions.

IV. CONCLUSION

A very significant climate warming has been noted on the territory of Karachay-Cherkessia. On average the air temperature over the 45-year period has increased by 1.7°C, and the increase in precipitation was 33.9 mm/year. Heat supply in the region reaches its highest values in the winter and summer-autumn months. Spring and autumn are characterized by increase in precipitation

The change in temperature with respect to increasing altitude of the terrain creates conditions for the inversion processes when there is a concentration of air pollutants. This increases the negative impact on public health. Such inversions are most often created during the cold season or during periods of cold snaps, especially in the resort and recreation zones of the middle lands, specifically, Teberda, Arkhyz, Dombay.

Gross emissions of pollutants from all sources of pollution into the air of Karachay-Cherkessia increased to 58.1 thousand tons per year and the city of Cherkessk is subject to 52.8% of them.

An increase in sources of pollution is noted in the mountain valleys of Kuban, Teberda, Bolshoi Zelenchuk, Urup and Bolshaya Laba, characterized by frequent cases of inversions of hydrothermal indicators, fogs, smogs, frost, etc., reducing atmospheric pollutants dispersion. Many of these pollutants are durable in the atmosphere and spread to the gorges by wind currents. Thus, a bluish haze observed over conifer forests in the summertime is an aerosol resulting from the photochemical oxidation of terpenes.

Analysis and comprehensive assessment of the structure and sources of air emissions, physiological features of the eastern spruce as well as observations of abnormal atmospheric phenomena in the gorges and valleys of Karachay-Cherkessia a priori point to the close relationship of spruce stands drying up with an increase in the concentration of suspended chemical compounds that reduce the quality of atmospheric air. It is recommended to consider the communities of Eastern Spruce in Karachay-Cherkessia as an indication object for monitoring air pollution caused by heavy metals aerosols.

The period of more than 15 years is characterized by the increased amount of gross emission of pollutants into the

atmosphere of Karachay-Cherkessia over a full-year cycle. Consequently, overall morbidity among the population of the republic has increased significantly.

The incidence of respiratory organs increased by 1.4 times and the nervous system incidence rose by 1.8 times. The rates of disease of other morbidity classes increased significantly and correlation with environmental factors is very high as well.

Monitoring of causal relationships between anthropogenic impurities in atmospheric air and the nature of morbidity enables to regulate regional environmental management objectively by creating a favorable environmental quality.

Virtually the entire territory of Karachay-Cherkessia with regards to natural and climatic indicators belongs to the category of a favorable recreational region. However, according to the complex indicators of comfort of individual regions and natural-geographical territories, economic activity, environmental quality and the state of the biosphere in the region, recreational zoning is adjusted.

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