Integrated assessment of ecological state of municipal economy objects in towns of caucasus mineral waters region

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Abstract. Despite the environmental attractiveness, the resort towns and cities of the Caucasus Mineral Waters (CMW) region face ecological problems concerning the condition of municipal economy objects, which require attention and solution. The present paper gives an analysis of the results of the investigation of ionizing radiation and dust factor in resort towns and cities of the CMW region. The results, obtained by the authors, prove the necessity of a wide-scale accumulation of data on the ecological characteristics of the municipal economy objects of the resort region. Based on the obtained results, the authors carry out the work aimed at the ecological mapping of the resort towns and cities of the CMW region, which involves assigning the “hazard” categories to the territories of various functional zones, i.e. a software product on the basis of the mathematical model of the environment is developed that allows performing an integrated calculation of the influence of negative factors, as well as setting the recommendations necessary for the normalization of the ecological situation in the most busy and troubled zones of the towns and cities. The given maps should be “mobile”, that means they should allow including all the changes in the ecological situation for a particular territory in a timely manner.

1. Introduction

The resort region of the Caucasus Mineral Waters (CMW), like other territories in Russia, faces specific ecological problems. Due to the assignment of the status of a resort of the federal importance to the region, the Russian Federation Government and the regional administration develop a series of programmes aimed at normalizing and improving the ecological situation. The System of ecological safety provides for the measures ensuring that the influence of negative and hazardous ecological factors on the environment and human health stays within the permissible values with the specified probability [1-6]. The main complex components of the given system are environmental management, environmental monitoring and the ecological assessment of territories, the logical interaction and interrelation of which allow solving the problems of ensuring the public ecological safety in a particular region [7-8].

In the recent years, the scientists working at North Caucasus Federal University and Volgograd State Technical University have co-organized the work aimed at the environmental monitoring of the factors and the ecological assessment of the territories of the CMW resort region [9-15]. The present paper considers the ecological factors of urban environment and justifies the necessity to carry out
investigations concerning the assessment of their integrated influence on the social and ecological well-being of people living in the resort-city of Pyatigorsk. In this paper, ionizing radiation and dust level of urban territories are presented as the ecological factors influencing the urban environment. For the purpose of the choice reasonability, it is necessary to consider each of the factors separately, and then to perform the integrated assessment of the urban territories.

2. Ionizing radiation
Ionizing radiation can occur as a result of emissions of radioactive radon into the atmosphere, radioactive atmospheric precipitations or radiation from materials used for the erection of buildings and constructions [13,14,16-18]. It should be noted that when the background ionizing radiation is considered, natural sources account for the largest proportion (about 70%), equipment and devices at medical institutions account for 29%, while the rest of the sources account for about 1% of the radiation.

The level of public exposure to radiation from natural sources is mainly formed by gamma radiation and the concentration of radon in the air environment of territories and buildings. The authors have carried out a wide-scale investigation of the level of equivalent dose rate (EDR) of gamma radiation for various territories of the resort towns and cities in the CMW region. The obtained results are not too alarming since the values equal to 0.15-0.30 µSv/h. An exception is the city of Lermontov for some territories of which the EDR values exceed 0.5 µSv/h. Up to now, the investigations of the radiation characteristics of gamma-radiation in residential buildings performed by the authors have not revealed any abnormally high values which amount to 0.18-0.42 µSv/h, in some buildings in Lermontov the values of more than 0.6 µSv/h have been registered. However, the impossibility to perform the measurements of the radiation characteristics in all the rooms in service poses the largest difficulties. Therefore, in the authors’ opinion, it is reasonable to create a single base of the values of indoor radiation characteristics which should be obligatorily obtained prior to the commissioning of any construction object according to the current legislation.

For the inhabited localities in the CMW region, the investigation of radon activity in the atmospheric air, in the indoor air and the natural waters serving as the source of public water supply should be paid the most careful attention [13-14]. The interest to the public exposure to radiation in the resort towns and cities of the CMW region has been generated by the specific features of the territory balneology that is among other things represented by radon waters and the vicinity of Beshtau Mountain that served as a source of uranium extraction for a long time.

A series of organizations deal with the investigations of radon activity in the region. In particular, according to the annual reports of the Federal Service for Surveillance on Consumer Rights Protection and Human Wellbeing “On the sanitary-and-epidemiological situation in the Stavropol Territory”, the average annual doses of public exposure to radiation in the CMW region due to the action of radon amount to 5 - 10 mSv/year. At the same time, the given values for the eastern group of inhabited localities in the Stavropol Territory do not exceed 2.5 mSv/year, and for Stavropol, the capital city of the Stavropol Territory they do not exceed 2 mSv/year.

The authors have organized a wide-scale monitoring of radon concentration in residential and public buildings in the towns and cities of the CMW region. The largest values of radon activity have been registered in the indoor air in the city of Lermontov located in the vicinity of Beshtau Mountain. The density of radon flow in the territory of Lermontov significantly exceeds both the Russian average values and the average values for other towns and cities of the CMW region. However, in the course of the examination of radon activity in the indoor air of the first floors of residential buildings in Pyatigorsk during winter period (2017-2018), it was determined that the value of equivalent equilibrium volumetric activity of radon exceeds the standard value of 200 Bq/m³ for more than 50% of the rooms.

In the course of the analysis of the levels of public exposure to radiation, it is necessary to take into account that the exceedance of the permissible standards can occur only for the residents permanently living in the resort region. While for the guests of the region the period of staying in the resort towns
and cities is, as a rule, no longer than 2-3 weeks, therefore no considerable contribution into the annual exposure to radiation is included.

Nowadays, the task concerning the mapping of radon characteristics of the towns and cities in the CMW region stays topical, the given map will allow avoiding the construction of buildings at radon-affected sites without special protective technologies applied.

3. Dust level in urban territories

The dust level of urban environment is a serious ecological and hygienic problem for many towns and cities. The negative impact of dust affects various spheres of human activity, it shows itself most explicitly in the sphere of municipal construction and economy. Medical investigations have revealed a direct dependence of the public disease incidence on the concentration and the total amount of dust in the ecosystem. High concentration of dust in the air environment primarily affects human respiratory organs, causing irreversible diseases. In addition, dust pollution exerts a negative effect on mental condition and human nervous system. The level of the negative impact and the consequences caused depends not only on the dust concentration but on the dust particle size distribution as well. It should be also noted that the amount of technology-related dust released to residential development often exceeds the amount of that arriving from natural sources [17-19]. In the Russian Federation, the normative document regulating the maximum permissible concentrations (MPC) for fine dust in the air of inhabited localities is the Hygiene standards GN 2.1.6.3492-17, and for suspended particles it is the Hygiene standards GN 2.1.6.1338-03, shown in table 1.

| Substance name       | Value of MPC, mg/m³ |
|----------------------|---------------------|
|                      | Maximum single one  |
|                      | Average day one     |
|                      | Average annual one  |
| Suspended substances | 0.5                 |
|                      | 0.15                |
|                      | 0.15                |
| Suspended particles PM_{10} | 0.3       |
|                      | 0.06                |
|                      | 0.04                |
| Suspended particles PM_{2.5} | 0.16    |
|                      | 0.035               |
|                      | 0.025               |

The analysis of the dust level of urban territories in the resort towns and cities is carried out together with the assessment of the size distribution of suspended dust particles. By the present time the authors have carried out the investigations of the dust level in the resort towns and cities of the CMW region. According to the obtained results, it has been revealed that the level of suspended particle exceeding of the maximum permissible concentrations given in table 1 is registered in numerous territories of urban up-built areas including the resort zones. The regularities of dust release from transport infrastructure and technology-related sources to the resort zones are considered in the works [12,20]. In this case, the maximum exceedance of the MPC has been registered for fine dust particles PM_{10} amounting to 1.15-2.5 times, no exceedance has been registered for dust particles PM_{2.5} [10,21-23]. Further, the lack of fixed monitoring stations observing the condition of the atmospheric air has been revealed for all the resort towns and cities of the CMW region. Taking into account the hazardous influence of fine dust on human health, the authors have organized the work aimed at investigating dust release into the atmosphere from various sources, they are also developing the technological tools intended for the reduction of the dust level of the atmospheric air. The results of the given investigations as well as the efficiency of the engineering solutions are thoroughly considered in the works [10].

4. Organization of the integrated approach to the assessment of the ecological condition of resort towns and cities of the CMW region

The main task of the integrated investigation of the ecological situation at the municipal economy objects of resort towns in the CMW region is the development of an electronic map of the towns involving the marking of the zones and levels affected by various factors of negative influence on the environment and human health, and a regular filling of the map with new data. To determine the
degree of the influence of a complex of factors (dust, radiation) they should be considered in whole as an entire unite, taking into consideration various correction coefficients for the degree of the influence etc. In the process of the negative influence assessment, the territory can be characterized in the following way: favourable, satisfactory or unsatisfactory. In order to refer a territory to this or that category of the influence, the authors are developing a mathematical model of the environment regarding for the complex of factors and their joint effect. In the course of the investigation of dust pollution and ionizing radiation, the authors are carrying out experimental investigations serving as the basis for the creation of the mathematical model of the migration of dust particles and radionuclides from the generating sources to various objects of construction and municipal economy.

The investigation work on the assessment of urban territories and the normalization of the ecological situation is based on the calculation algorithm and the software program for the assessment of the ecological condition of urban environment under the joint influence of negative factors. Further, the obtained data should be used for the creation of an electronic map of a town or a city which will allow revealing the most troubled zones requiring that measures aimed at reducing the negative influence are conducted.

The given paper considers only two ecological factors influencing the ecological situation at the municipal economy objects in the towns and cities of the CMW region. In addition to those, there are other factors formed in the process of human technogenic activity and immediately influencing the ecological state of the territories, such as gas contamination of the atmospheric air, vibration levels, the ecological condition of drinking and mineral waters etc. In the authors’ opinion, it will be reasonable to complement the presented scheme with additional factors in the course of further investigations, as well as to combine the efforts of scientists working for various organizations in order to show a true picture of the ecological state of resort towns and cities of the CMW region, and in the case of necessity to jointly develop the most acceptable solutions aimed at bringing the ecological characteristics to the standard values.

5. Conclusion
Despite the environmental attractiveness of the territory, the municipal economy of the CMW region faces ecological problems which require a detailed analysis and development forecasting. The present paper justifies the necessity to organize investigations of ionizing radiation and the level of the equivalent dose rate of gamma radiation of the territories, as well as to develop measures aimed at the reduction of those. For particular urban territories of CMW region, it is necessary to perform an integrated assessment of ecological factors, on the basis of which the level of public well-being should be determined and the relative decisions should be made.

It is required to develop ecological maps of the towns and cities involving the assignment of the “hazard” categories to the territories of various functional zones and regularly fill the maps with new data. Such a map is a software product based on the mathematical model of the environment that allows performing an integrated calculation of the influence of negative factors, as well as setting the recommendations necessary for the normalization of the ecological situation in the most busy and troubled zones of a town. The given map should be “mobile”, that means it should allow including all the changes in the ecological situation for particular territories in a timely manner. The given map should be “mobile”, that means it should allow including all the changes in the ecological situation for particular territories in a timely manner.

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