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Geoinformation Diagnostics of Natural and Anthropogenically Transformed Geosystems. Database Creation

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***Abstract*—Pollution of the environment, besides doing harm to nature, leads to various diseases of the population living in the contaminated area, including cancer diseases. Environmental pollution of the territory of the Republic of North Ossetia-Alania is mainly caused by enterprises of non-ferrous metallurgy and motor transport. Vladikavkaz, the capital of the republic, where the main stationary sources of pollution are located and the number of vehicles is the largest, is exposed to the hardest pollution. In rural areas of the republic, the state of atmospheric air is consistently satisfactory because of the absence of large industrial enterprises in the countryside and a smaller number of motor transports. The material on the population morbidity of malignant growth in various regions of Vladikavkaz was selected. The functional dependence of the patients' percentage on the age group with a high value of approximation reliability was obtained. The main proportion of newly registered malignant neoplasms falls to age groups over 60 years. The analysis of cancer morbidity showed that in the areas of the republic, as well as in Vladikavkaz, where the level of environmental pollution is higher, the rates of cancer morbidity are higher.**

Keywords—mountainous region; extraction of minerals; heavy metals; pollution of environment; cancer morbidity.

I. INTRODUCTION

In the modern world, there are opportunities to receive in a relatively short time a huge amount of information about certain features of different investigated objects, which can be fully processed only with the use of modern computer technologies. Due to the fact that the prevailing number of different factors has a spatial reference, it is necessary to develop not just information, but geoinformation support. That is why geoinformation technologies and methods have become one of the main tools for carrying out environmental study, as well as for assessing and monitoring of the state of the natural environment and resources. The development and implementation of new methods of modeling the objects behavior, the movement or propagation of this or that geophysical process, is an important task for the determination of the relationship and correlation of spatial distributions of various physical fields.

The pollution of the environment is a complex and multifaceted problem, but the main one is the unfavorable effects on the population health. Environmental pollution affects more the health of the urban population [1-3, 5-6]. According to numerous studies, unfavorable environmental factors can cause significant health disorders even at low levels of exposure. Pollution of the environment, in spite of relatively small concentrations of substances and due to the long duration of exposure, can lead to serious diseases, including cancer [4].

II. ENVIRONMENTAL POLLUTION AND CANCER MORBIDITY OF THE POPULATION OF THE REPUBLIC OF NORTH OSSETIA-ALANIA

One of the aims of investigation was the analysis of

environmental pollution and cancer morbidity of the population of the Republic of North Ossetia-Alania, according to the state reports "On the state and protection of the environment and natural resources of the Republic of North Ossetia-Alania" of the Ministry of Natural Resources and Ecology of the Republic of North Ossetia-Alania and "On the state of sanitary and epidemiological welfare of the population in the Republic of North Ossetia-Alania" of the Department of Federal Service for Supervision of Consumer Rights Protection and Human Welfare of the Republic of North Ossetia-Alania for 2010-2016.

The material on the population morbidity of malignant growth in various regions of Vladikavkaz was selected [8]. A special database for processing and subsequent analysis of the obtained data was developed. The forming parameters of the base included the residence, sex, age of the patient, localization of the lesion of the patient's body. Database connection to the digital map in the geographic information system made it possible to perfom multiple data analysis due to the spatial reference of each record [9-10]. The distribution of the malignant growth morbidity across the city's area was made on the schematic map of the city in GIS technologies. According to the standard method of polyclinic territorial zoning within the polyclinic service boundaries, morbidity rates for different years were obtained, as well as the mean value for several years [11], which was put on the map (Fig. 1).

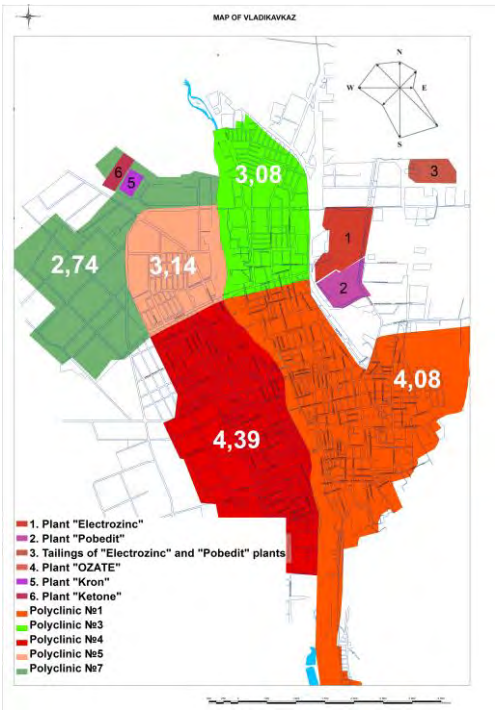

Fig. 1. Neoplasms morbidity within the territory of city polyclinics.

The pollution of the environment in the Republic of North Ossetia-Alania occurs owing to the stationary and mobile sources. Stationary sources include industrial enterprises, which are represented in the republic by such branches as non-ferrous metallurgy,machine building and metal processing, electric power industry, fuel industry, timber and wood-working industry, construction materials production [12-14, 19-20]. The main stationary sources of air emissions are the enterprises of metallurgical industry [15-17]. A major contribution to environmental pollution is made by mobile sources, in particular by motor vehicles, the number of which is growing rapidly from year to year.

Data on air emissions from stationary sources in North Ossetia-Alania for 2010-2016 are presented in Table I.

TABLE I. AIR EMISSIONS FROM STATIONARY SOURCES IN NORTH OSSETIA-ALANIA FOR 2010-2016 (THOUSAND TONS)

Indicator name	2010	2011	2012	2013	2014	2015	2016
Total amount	5.018	4.045	4.391	5.032	3.484	5.283	4.545
Including							
Solid	0.628	0.298	0.283	0.246	0.337	0.296	0.412
Gas and liquid, among them:	4.390	3.747	4.107	4.786	3.147	4.987	4.132
Sulphur dioxide	0.894	0.561	0.5	0.288	0.332	0.328	0.357
Carbonic oxide	2.204	1.836	1.698	1.535	1.493	1.443	1.449
Nitrogen oxides	0.719	0.131	0.117	0.31	0.269	0.268	0.253
Hydrocarbons	0.574	1.038	1.617	2.491	0.854	2.678	1.780
Volatile organic compounds	0.194	0.086	0.069	0.079	0.098	0.196	0.197
Other gas and liquid	0.223	0.095	0.106	0.082	0.102	0.074	0.096

It should be noted that the largest number of atmospheric contaminators is located within Vladikavkaz, the capital of the Republic. Their emissions reach 60% of all air emissions from stationary sources in the republic. The state of atmospheric air in rural areas is consistently satisfactory. This is due to the absence of large industrial enterprises in the countryside and a smaller number of motor transport and other contaminators.

Taking into account the fact that Vladikavkaz is more exposed to environmental pollution, soil pollution with heavy metals (which play an important role in the origin of cancer) has also been analyzed (Table II).

TABLE II. SOIL POLLUTION IN THE SECTION OF THE DISTRICTS OF VLADIKAVKAZ FOR 2010-2016.

Pravoberezhny district

Pollutants	Specific weight of non-standard samples in the following years						
	2010	2011	2012	2013	2014	2015	2016
Lead	125.4	154.5	170.2	174.1	169.0	184.4	176.7
Cadmium	47.5	169.6	154.5	124.4	150.0	165.2	171.9
Zinc	110.1	167.0	138.6	126.3	152.4	162.2	176.2
Copper	25.6	23.2	3.0	15.6	9.5	6.6	9.5

Levoberezhny district

Pollutants	Specific weight of non-standard samples in the following years						
	2010	2011	2012	2013	2014	2015	2016
Lead	148.1	81.0	87.5	97.8	101.2	139.6	171.3
Cadmium	119.9	72.7	133.3	97.8	78.6	93.8	116.0
Zinc	105.6	69.3	166.7	73.3	98.0	64.6	135.3
Copper	4.8	0	0	0	0	6.3	0

The most polluted area of Vladikavkaz is the Pravoberezhny district, which includes the Iristonskiy and Promyshlenniy municipal districts, where over 132,000 of the city's population live. Among the municipal districts the most

polluted is the Promyshlenniy district, where large industrial enterprises are situated.

Previous studies have shown that the closer the soil is to the industrial enterprises of non-ferrous metallurgy and halos contaminated with heavy metals, the higher the cancer morbidity of the population of Vladikavkaz is [18]. The indicators of newly diagnosed cancer morbidity in North Ossetia-Alania for 2010-2016 are given in Table III.

TABLE III. COMPARATIVE TABLE OF THE NEWLY DIAGNOSED CANCER MORBIDITY IN NORTH OSSETIA-ALANIA FOR 2010-2016 (PER 100 THOUSAND OF POPULATION)

Districts	2010	2011	2012	2013	2014	2015	2016	Average long-term level for 7 years
RNO-Alania	292.6	287.7	315.2	337.1	311.7	304.7	295.3	306.3
Alagirskiy	369.6	360.4	338.7	407.2	356.1	330.1	321.1	354.7
Ardonskiy	299.3	267.1	314.8	318.3	329.3	265.9	293.3	298.2
Digorskiy	348.4	310.4	351.2	356.4	289.6	388.0	375.6	345.6
Irafskiy	321.5	278.9	357.7	425.0	268.2	287.3	287.3	317.9
Kirovskiy	238.9	190.5	205.5	246.1	261.6	295.1	244.4	240.3
Mozdokskiy	260.0	249.5	283.3	254.6	279.5	258.5	282.2	266.8
Pravoberezhny	301.5	263.1	323.9	290.3	325.6	283.1	307.7	299.3
Progorodniy	240.8	244.2	250.4	229.9	261.6	246.6	255.5	247.0
Vladikavkaz	307.4	319.7	365.4	349.1	334.6	337.1	306.7	331.4

In the long-term dynamics of the studied period (2010-2016), the main specific weight in the structure of cancer morbidity in the republic belongs to skin cancer. Breast cancer takes the second place. And lung cancer – the third.

The main specific weight of newly registered malignant neoplasms falls to age groups over 60 years. Correlation dependence of the share of the diseased on the age group was determined by calculation (in the GIS system) of the total number of cancer morbidity cases at the polyclinic service boundaries [18]. Using the average value of the number of cases of cancer diseases in polyclinics and making a diagram of dependence of the share of patients on the age group, the shape of the approximating curve was obtained by the least squares technique (Fig. 2). This type of curve has a clearly expressed quadratic form, which was taken into account in its construction. Taking such a high level of reliability of the approximation $R^2 = 0.989$, we can conclude that the obtained equation describes the given dependence very accurately.

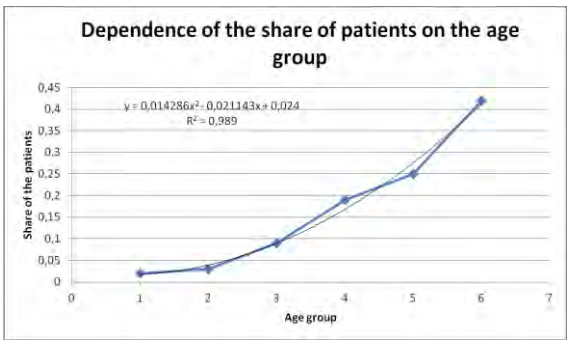

Fig. 2. Dependence of the share of patients on the age group.

With the help of the determined dependence, the expected number of cancer cases for Alagir was calculated and a comparison with the actual data was made (Table 4). As the Table 4 shows, the difference between real and calculated values does not exceed 3% of the total number of oncological patients.

TABLE IV. DEPENDENCE OF THE NUMBER OF CANCER CASES ON AGE GROUPS FOR ALAGIR

Total number	18-29	30-39	40-49	50-59	60-69	70 and over
Number of cancer cases in different age groups						
352	12	21	37	56	86	140
Prognostic number of cancer cases in different age groups						
352	7	11	32	67	88	148

The study of the dependence of the number of diseases on the distance to pollution sources (the plants “Electrozinc” and “Pobedit” located in Vladikavkaz) was also carried out. Analysis of the population morbidity in the Prigorodny district shows that with the distance from the dumps of “Electrozinc” and “Pobedit” plants, the morbidity significantly decreases for the nearby settlements (Fig. 3).

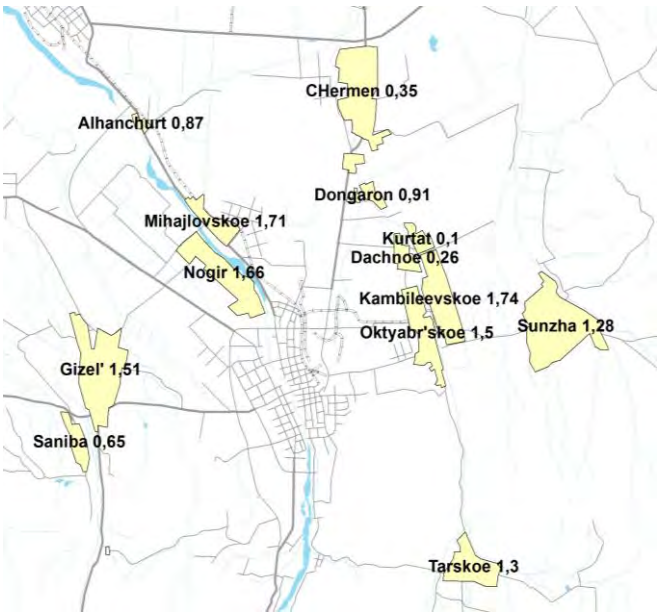

Fig. 3. The map of morbidity in Prigorodny district.

Thus, the analysis of cancer morbidity showed that in those areas of the Republic, including Vladikavkaz, where the level of environmental pollution is higher, the rates of oncological morbidity are also higher.

III. CONCLUSIONS

1. Environmental pollution of the territory of the Republic of North Ossetia-Alania is mainly caused by the integrated impact of dumps of the enterprises of non-ferrous metallurgy and motor transport.

2. Vladikavkaz, the capital of the republic, where the main contaminators are located and the number of vehicles is the largest, is exposed to the hardest pollution.
3. Thereafter the most polluted area is Pravoberezhny district, where large industrial enterprises, which are contaminating the environment with heavy metals, are situated.
4. The material on the population morbidity of malignant growth in various regions of Vladikavkaz was selected. A special database for processing and subsequent analysis of the obtained data on cancer morbidity of the population, living in the region with intensive mining industry, was developed.
5. The cancer morbidity is higher on the territories where the pollution of the environment with heavy metals is higher. It is determined the closer the soil is to the industrial enterprises of non-ferrous metallurgy and halos contaminated with heavy metals the higher the cancer morbidity of the population.
6. The functional dependence of the patients' percentage on the age group for Vladikavkaz with a value of approximation reliability R^2=0.989 was obtained by the least squares technique.
7. With the help of the determined dependence, the expected number of cancer cases for Alagir, situated at a distance of 37 km from Vladikavkaz along the straight line, was calculated and compared with the actual data. The difference between real and calculated values does not exceed 3% of the total number of oncological patients. Thus, an empirical expression has been obtained for calculating the expected number of cancer patients for regions with heavy metal contamination, which requires verification at other sites.

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