

# The Problems of the North Caucasus Landscape's Pollution and Population's Health

Vladimir V. Diyachenko, Yyriy A. Malykhin, Larisa G. Diyachenko

Novorossiysk Polytechnic Institute (Branch) of the Kuban State University of Technology, Novorossiysk, Russia.  
Email: [v-v-d@mail.ru](mailto:v-v-d@mail.ru), [yuranya86@mail.ru](mailto:yuranya86@mail.ru)

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## ABSTRACT

The article is devoted to analysis of the atmosphere and soil pollution's monitoring and health status of the Krasnodar region city's population (the South of the Russian Federation). Studies were conducted during more than 20 years, and there was repeated testing of the soil in various regions and cities. The results indicate an increase of the atmosphere pollution and of the concentrations of chemical elements in soil and deterioration of health of the population as a consequence. Especially the children and adult population with diseases of the respiratory tract strongly increased. The population medical records studies are based on the health research and the atmosphere and the soil chemical analysis results in the pollution monitoring. Ni, Cr, Cu and Pb concentrations in the region soils increased during the observation period. The highest degree of air pollution in southern Russia was marked in Novorossiysk.

## KEYWORDS

Atmosphere; Pollution; Health; Soil

### 1. Introduction

Due to different mobility, assimilation potential, accumulation ability and ability to self-purification, the growing pollution of the earth's ecosystems and the biosphere's "metallization" have a different manifestation and consequences in naturtechnisches geosystems. The most movable geosphere of the earth is atmosphere, and the most conservative depositing environment is soil. The soils, being on intersection intralandscape migration torrent, have possessed brightly expressed cation absorptive ability with intensive accumulates and firmly held positively charged ions. By some data [1,2], the metals have been much slowly removed from the soils during leaching process, erosions, plants' consumption. Their natural half-life period can occur for hundreds and thousands of years (Pb—from 740 to 5900 years, Cu—from 310 to 1500 years, Zn—from 70 to 510 years and etc.). Studying the distribution, the interrelation and migration of chemical elements processes in soils, we estimated the landscape's development history, gauged the environ-

ment condition, established the specific factors of its functioning and impact of cross-border migration flows (including overhead).

The atmosphere is the migration environment within which the movement of pollutants on the vast distances occurs in only a short time. At the same time, due to high mobility and turbulence of air flows, the chemical composition of the air at a particular point changes rapidly and evolves quickly. On the contrary, the soils can accumulate chemical elements and keep high concentrations for a long time after pollution. Therefore, during the study of how air pollution factors have influence on the human health, it is appropriate to operate parameters of the soils state as the objective confirmation and an illustration of the intensity and durability of pollution.

### 2. Materials and Methods

To determine the scale and intensity of pollution of landscapes of the Northern Caucasus, the atmospheric air pollution and the concentrations of chemical elements in

soils dynamics at various regions and cities were studied. Especially there were studied the landscapes and settlements of the Krasnodar region. Soils of these and some other South Russia territories were evenly tested from 1980 till 2012. The main object of testing was humussoil horizon "A", (to a depth of 15 - 20 cm) most subjected to pollution. Shared database includes more than 9000 soil's samples analyzed for the contents of 20 - 25 microelements. All laboratory results statistically processed and presented in mass fractions or %.

As an integral environment's total anthropogenic impact it has been examined the condition and factors determining the health of the population at Novorossiysk, one of the most polluted cities in the South, and throughout the Russian Federation.

### 3. Results

#### 3.1. Analysis of the North Caucasus Landscape's Pollution

Object of research is the South of the Russian Federation, the cities of Krasnodar region, which next year will be hosting the winter Olympic Games. More detail and in terms of the health of people there were considered, Novorossiysk city. Unfortunately, the Krasnodar region and our city are developing in line with worldwide trends. Natural landscapes, giving place to pipelines, power lines, industrial enterprises, quarries, roads, settlements. As result, the degree of cultivated plains part reaches 80%. Particularly affected marshes and forested areas in the black sea zone. Over the past 50 years, the area of natural landscapes decreased by 20% - 25%.

Anthropogenic transformation of the biosphere has results to not only visible changes, but also to the chemistry transformation of the environment. As a result of pollution in soils of the major regional landscapes of the South of Russia (Rostov region, Krasnodar region, North

Ossetia) during 15 - 25 years, concentration of Ni and Cr increased at 1.5 - 2.5 times; Cu and Pb at 1.5 - 1.7 times. The concentrations of Zn, Co, Ag, Sn, Sr, Be increased in varying degrees [3]. In General, it is a worldwide problem that is reflected even in global terms, as Clarke of soils. If we'll place Clarke, calculated by different authors by the time of their definitions: A.P. Vinogradov—40-50-ies, A. Kabata-Pendias—60-70-e, Shacklette H. T., Boerngen J. G. US—70, A.B. Ronov and A.A. Yaroshevsky—70-80-s, Diyachenko V.V the North Caucasus—80 - 90s, it will appear that the concentrations of elements of high technophilia has been increase (15 of 25 examined) and many almost consistently (Table 1).

Within the sources of pollution (industrial and transport company, highways, military facilities, landfill, boiler rooms and other) and directly adjacent zones, the levels of soil pollution even higher (Table 2).

The enhanced concentration of microelements in soils of settlements is due to the high degree of their technogenic transformation and concentration of the objects which affects the environment. Moreover, the intensity and the specifics of pollution has depends of the size and geochemical peculiarities of industrial enterprises. Therefore, higher pollution characterized Krasnodar and Taganrog. This becomes obvious through comparing the cities in similar natural conditions—Novorossiysk and Gelendzhik. Industrial Novorossiysk is much stronger dirty than resort Gelendzhik (Table 3).

The big cities of the South Russia were contaminated by the majority of highly toxic chemical elements. Relatively Clarke of soils, in descending order of the values of the sum of Kk (Table 3) line up: Taganrog (69.2) > Krasnodar (48.3) > Novorossiysk (36.3) > Gelendzhik (29.6). The permissible level of them is less than 16. It is important to pay attention to the rate of increase in the concentrations of chemical elements, more precisely, the total contamination of soils in Table 3. The current

**Table 1. Comparison of the chemical elements average concentrations in soils of the Northern Caucasus with soils Clarke of the world and the United States ( $n \times 10^{-3}\%$ ).**

| Element | Clarke of soils                                 |                                                                  |                                                                   |                                                               |                                                                |
|---------|-------------------------------------------------|------------------------------------------------------------------|-------------------------------------------------------------------|---------------------------------------------------------------|----------------------------------------------------------------|
|         | Vinogradov, 1957<br>(for soils of the world)[4] | Kabata-Pendias,<br>Pendias, 1979 (for soils<br>of the world) [1] | Shacklette H. T.,<br>Boerngen J. G. 1984<br>(for the US soil) [6] | Ronov and<br>Yaroshevsky 2000 (for<br>soils of the world) [5] | Dyachenko, 2004<br>(for soils of the<br>Northern Caucasus) [3] |
| Ba      | 50.0                                            | 21.0-63.0                                                        | 58.0                                                              | 50.0                                                          | 72.0                                                           |
| Zn      | 5.0                                             | 6.0                                                              | 6.0                                                               | 6.0                                                           | 10.6                                                           |
| Cu      | 2.0                                             | 2.0-3.0                                                          | 2.5                                                               | 2.3                                                           | 5.1                                                            |
| Pb      | 1.0                                             | 2.5                                                              | 1.9                                                               | 2.0                                                           | 3.5                                                            |
| Co      | 0.8                                             | 0.85                                                             | 0.91                                                              | 0.9                                                           | 2.01                                                           |
| Sc      | 0.7                                             | 0.15-1.25                                                        | 0.89                                                              | 0.8                                                           | 0.96                                                           |
| W       | 0.13                                            | 0.07-0.27                                                        | 0.12-0.25                                                         | 0.1                                                           | 0.22                                                           |

**Table 2. The heavy metals average concentrations ( $n \times 10^{-3}\%$ ) in the soils of the settlements of the South of Russia.**

| Element | Sources of pollution | Objects of pollution | Regional soils' Clark for the Northern Caucasus |
|---------|----------------------|----------------------|-------------------------------------------------|
| Mn      | 224.2                | 132.1                | 93.0                                            |
| P       | 95.3                 | 116.5                | 89.0                                            |
| Zn      | 30.1                 | 25.5                 | 10.6                                            |
| Cr      | 32.7                 | 14.6                 | 10.9                                            |
| Cu      | 8.5                  | 6.8                  | 5.1                                             |
| Ni      | 7.3                  | 6.0                  | 4.7                                             |
| Pb      | 21.5                 | 13.9                 | 3.5                                             |
| Sn      | 0.70                 | 0.70                 | 0.56                                            |
| Ag      | 0.17                 | 0.07                 | 0.01                                            |

**Table 3. Integral geoeological estimation of soil residential landscapes.**

| Residential landscapes | Year of testing | Regarding                           |                                                       |
|------------------------|-----------------|-------------------------------------|-------------------------------------------------------|
|                        |                 | Soils of the Earth ( $\Sigma K_k$ ) | Regional soils of the North Caucasus ( $\Sigma K_k$ ) |
| Krasnodar              | 1991            | 48.3                                | 10.8                                                  |
| Taganrog               | 1995            | 69.2                                | 9.9                                                   |
| Novorossiysk           | 1991            | 25.3                                | 4.2                                                   |
| Novorossiysk           | 2003            | 36.7                                | 13.8                                                  |
| Gelendzhik             | 1996            | 14.8                                | 2.3                                                   |
| Gelendzhik             | 2003            | 29.6                                | 7.1                                                   |

situation in Gelendzhik better than in Novorossiysk, but the rate of pollution above.

### 3.2. Pollution of the Atmosphere

The high degree of soil pollution and the dynamics of concentrations are closely related with atmospheric pollution. In recent years it has been visible the growth of the polluting substances emissions in the Northern Caucasus, Krasnodar territory (Figure 1) and especially in Novorossiysk (Table 4).

The volume of emissions in Novorossiysk exceeds the pollution in the largest cities and provides 25% of emissions of the Krasnodar region. No wonder Novorossiysk consistently ranks among the 20 most polluted cities of the Russian Federation, and by the results of 2011 even took the first place. The scale of aerogenic contamination is confirmed by the results of direct studies of the atmospheric air. In 2010, within two weeks, it was selected over 600 air samples in all parts of Novorossiysk and analyzed 4 components. So comparison with Russian Federation regulations showed that the excess  $H_2S$  de-

tected in 4% of the samples,  $NO_2$  - 6%,  $NO$  - 30%,  $CO$  - 54%. Moreover, work was carried out in a relatively prosperous time in late October. Already the mass of tourists subsided, the number of vehicles has decreased, there were no inversion in the atmosphere, improved conditions for mixing of surface air etc. As expected the majority of samples found to contain elevated concentrations, taken in the industrial Eastern part of the town and along the tense roads. In 2012, the critical situation formed with formaldehyde atmosphere pollution. The average annual concentration exceeded norms 8.3 times, and in January the average monthly concentration exceeded 41.6 times. In addition to formaldehyde great contribution to the pollution of the atmosphere contribute: benz/a/pyrene, suspended substances, nitrogen oxides and carbon.

Certainly, the intensification of air pollution could not pass in vain for the ecological environment and the population. In recent years, in Krasnodar and Novorossiysk air pollution is estimated as high (III degree), and air quality adversely. Airgenetic impact on population health is one of the leading, therefore, air pollution in cities is the main factor of negative influence on health of the population and the basic hygienic problem.

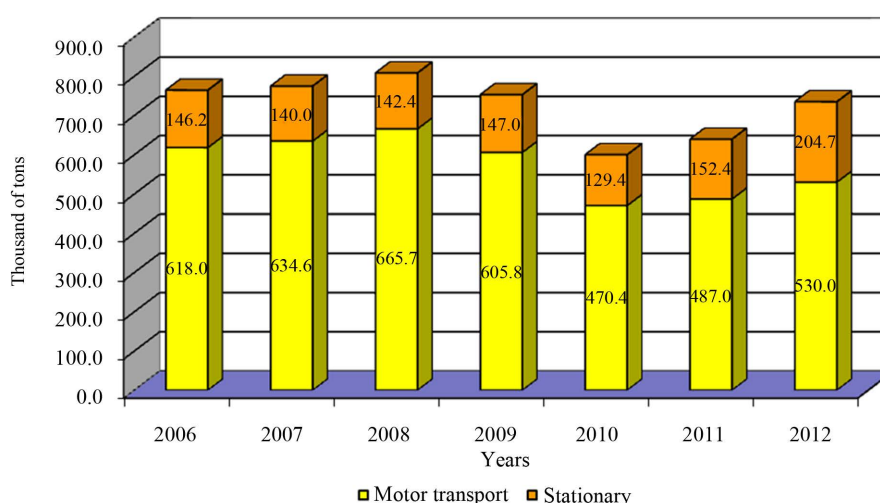
### 3.3. The Health of the Population

Periodic assessment of the urban territories ecological state is one of the most important aspects of safety. Such an assessment should be held with the obligatory account of factors which influencing on the processes of concentration of chemical compounds. The most important among these factors are:

- ecological-geochemical features of pollution sources;
- number of floors and the age of the city construction;
- greenery structure;
- physico-chemical characteristics of soils;
- the city's relief circumstances;
- meteorological characteristics;
- type of subsoil rocks.

The interaction of these factors has determines the structure of the urban territory pollution. However, there is a measure that helps to assess the quality of the urban environment in General. This is the state of the population health. Such an assessment solves two problems at once—the definition of luxury stay in a particular area, secondly—identification of the relationship morbidity with specific anthropogenic and natural features of the territory for development of measures on ecological situation improvement.

In the 1990 - 2000-ies we carried out complex environmental research in the coastal cities of southern Russia [7]. Including examined the incidence of children and adult population. The most informative is the first group, because of the most part of the life holds in a limited area,



**Figure 1.** Dynamics of pollutant emissions vehicles and stationary sources in the Krasnodar region (Thousand of tons).

**Table 4.** Dynamics of emission of polluting substances into atmospheric air from stationary sources in the cities of Krasnodar region.

| Year | Emissions of polluting substances by cities actual mass (thousand of tonnes) |              |       |         |              |       |
|------|------------------------------------------------------------------------------|--------------|-------|---------|--------------|-------|
|      | Krasnodar                                                                    | Novorossiysk | Sochi | Armabir | Delorechensk | Anapa |
| 1999 | 9.9                                                                          | 12.1         | 6.0   | 1.4     | 1.5          | 1.0   |
| 2000 | 9.7                                                                          | 18.3         | 4.2   | 1.4     | 1.1          | 0.7   |
| 2001 | 9.8                                                                          | 20.2         | 5.0   | 1.6     | 1.0          | 1.4   |
| 2002 | 9.2                                                                          | 25.5         | 3.8   | 1.2     | 1.4          | 0.4   |
| 2003 | 9.0                                                                          | 28.0         | 3.6   | 1.4     | 1.4          | 0.5   |
| 2004 | 8.2                                                                          | 30.1         | 3.4   | 1.3     | 1.4          | 0.4   |
| 2005 | 9.8                                                                          | 30.2         | 3.5   | 1.2     | 1.6          | 0.4   |
| 2006 | 9.8                                                                          | 38.2         | 3.1   | 1.3     | 1.5          | 0.4   |
| 2007 | 8.6                                                                          | 37.6         | 3.6   | 1.2     | 1.4          | 0.6   |
| 2008 | 9.9                                                                          | 37.4         | 3.0   | 1.4     | 2.0          | 1.6   |
| 2009 | 8.2                                                                          | 38.0         | 2.8   | 1.4     | 1.4          | 1.5   |
| 2010 | 8.1                                                                          | 39.4         | 2.7   | 1.5     | 1.8          | 1.2   |
| 2011 | 19.8                                                                         | 43.1         | 2.4   | 1.7     | 1.8          | 1.1   |
| 2012 | 10.7                                                                         | 51.4         | 3.6   | 3.5     | 1.9          | 1.3   |

so the linkages between environmental conditions and their health condition is more reliable. The emphasis was on diseases of the respiratory tract, so as to adverse environmental conditions reacted respiratory and circulatory system. After data collection it was carried out an analysis of the relationship of the number of diseases in particular areas of the urban environment with their environmental characteristics. The survey revealed two typical types of relationships:

- 1) The connection of morbidity and landscape-zonal peculiarities of the structure of the city's territory;
- 2) The connection of morbidity with pollution in some parts of the urban environment.

In the first case, the clearest link is established between the incidence of urban population and structure of urban development, the proximity to sources of pollution. **Tables 5** and **6** show the average long-term data on the incidence of children and adults, Novorossiysk, living in the areas with a various number of storey building.

It is characteristic that in both cases the maximum percentage of respiratory system diseases diagnosed in zones 1 - 2 storey buildings, and the lowest in the zones of high-rise buildings. Such distribution of the incidence has a several reasons:

- using of coal and firewood in the heating systems of one-storied residential zone. The combustion of them emitted a significant amount of carbon oxide and dioxide and ash containing toxic elements;
- release of pipes of heating systems compounds which promote to coagulation and precipitation of urban air pollutants migrating from industrial sources by air;
- underdeveloped network of sewerage communications;
- weak (often lack) of a centralized system for disposal of garbage;
- the introduction into the soil significant number of trace elements (particularly zinc, lead, mercury, silver, chromium, arsenic) with fertilizers and pesticides;
- the advanced age of the building and, as a consequence, the duration of anthropogenic impact;
- and most importantly, it is the proximity to industrial objects and the high level of air pollution in Novorossiysk, increasing approaching the surface of the Earth.

From the data presented in **Table 7**, it is seen that the closer is located the residential zone to industrial, the

**Table 5. Incidence children aged 2 to 14 years old living in areas with different height buildings, Novorossiysk (% from the number of patients).**

| Disease           | Number of Storeys |       |          |
|-------------------|-------------------|-------|----------|
|                   | 1 - 2             | 3 - 5 | 6 & more |
| Rhinitis          | 40                | 35    | 25       |
| Laryngitis        | 45                | 25    | 30       |
| Bronchitis        | 55                | 35    | 10       |
| Tracheitis        | 45                | 35    | 20       |
| Tracheobronchitis | 40                | 45    | 15       |
| Bronchial asthma  | 80                | 15    | 5        |

**Table 6. Incidence of the working-age population living in areas with different height buildings (% from the number of patients), Novorossiysk.**

| Disease                                | Number of Storeys |       |          |
|----------------------------------------|-------------------|-------|----------|
|                                        | 1 - 2             | 3 - 5 | 6 & more |
| Tuberculosis of the respiratory organs | 45                | 25    | 20       |
| Pneumonia                              | 50                | 35    | 15       |
| Pleurisy                               | 35                | 35    | 30       |
| Bronchitis chronic                     | 60                | 30    | 10       |
| Acute bronchitis                       | 30                | 40    | 30       |
| Bronchial asthma                       | 80                | 15    | 5        |
| Lung cancer                            | 75                | 15    | 10       |

**Table 7. Incidence (%) children aged 2 to 14 years, living in Novorossiysk at varying distances from major industrial zones.**

| Disease           | Remoteness from the industrial zone |              |                  |
|-------------------|-------------------------------------|--------------|------------------|
|                   | Less than 500 m                     | 500 - 1000 m | More than 1000 m |
| Rhinitis          | 70                                  | 25           | 5                |
| Laryngitis        | 65                                  | 25           | 10               |
| Bronchitis        | 65                                  | 15           | 20               |
| Tracheitis        | 55                                  | 45           | 10               |
| Tracheobronchitis | 80                                  | 15           | 5                |
| Bronchial asthma  | 100                                 | 0            | 0                |

higher the level of morbidity of the respiratory systems of children.

Thus, the incidence of the population (in particular respiratory tract) almost directly connected with environmental pollution. That is why when developing

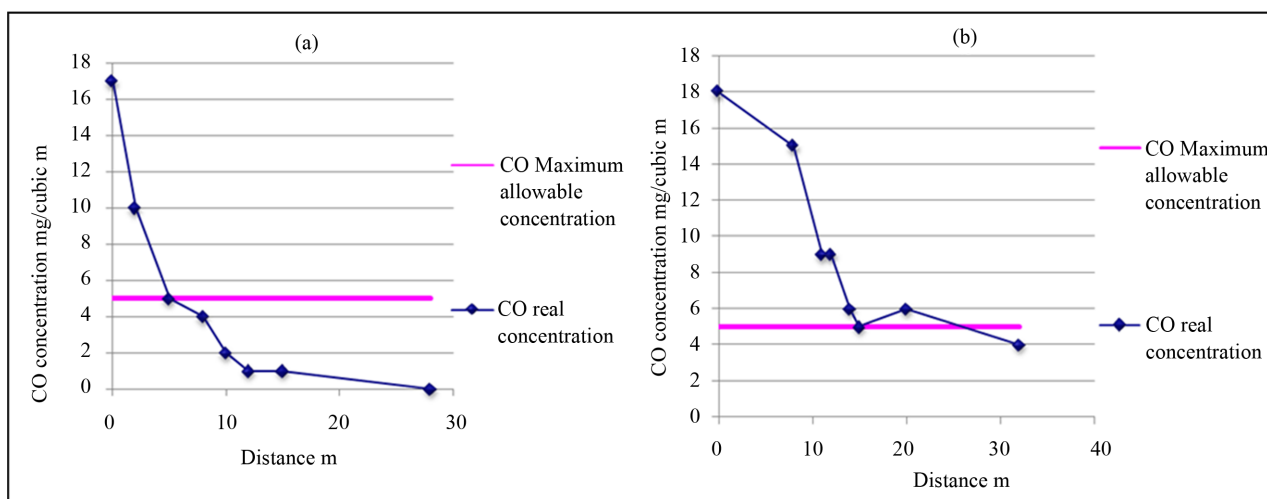
measures for raising ecological comfort of the citizens dwelling in the first place it is necessary to carry out complex researches, including geo-ecological zoning of the settlements territories, the assessment of their pollution and medico-biological investigations.

### 3.4. Green Areas and Air Pollution

The most important factor in air pollution is the planting greenery, but construction sites are multiplying, circum-cision natural landscape is enhanced (Tsemesskaya grove in Novorossiysk), the number of transport and industrial enterprises grows exponentially increased and gas and dust emissions into the atmosphere. The importance of planting greenery can be illustrated by the results of scientific work of the students of the Novorossiysk Polytechnic Institute [8]. The study of city playgrounds' air pollution showed that even when fifteen times exceeding environmental standards of the Russian Federation of pollutants on the highway, the presence of two rows of trees and bushes along the road leads to a sharp fall concentrations are already at a distance of 5 - 10 m (**Figure 2(a)**). In case of absence of vegetation along the road air pollution extends to dozens of meters (**Figure 2(b)**).

## 4. Conclusion

These data testify about the rapid dangers of environmental pollution, particularly of the air, and characteristics for most cities in the South of Russia. To remedy the situation, we must do the following. In the first place, full environmental offices empowered with supervisory and analytic functions should be created, in collaboration with the large industrial cities' municipalities (modern legislation environmental monitoring at the municipal level is limited only to domestic waste). Secondly, the dangerous enterprises with large-scale sources of the environment's pollution should ensure independent, objective information about the current status on the profile pollution. The most informative efficiency have automatic remote monitoring tool with good spatial-temporal resolution, better subordinate to the emergency services of the city. Organizing such monitoring is possible using laser technology, due to the high sensitivity and selectivity, as well as the speed in processing of measurement results which can be a basis for monitoring of pollutant emissions above the industrial enterprises. Moreover, the complex monitoring can be combined on a single platform aerosol lidar (for the control of air pollution, suspended solids) [9], for example, frames of the emission control system of hydrocarbons or other components. Such a system can work in the given algorithm around the clock, forming a three-dimensional model of pollution. Also it may change the periodicity of measurements and signal at a given level of excess concentrations.



**Figure 2.** Dependence of the CO concentration in the air by the distance from highways (a -with the presence of roadside green plantations, b - without roadside green plantations).

Thanks to long range (up to 6 km) and high accuracy (7 - 8 m), this system immediately determines the place and time of an accidental emission, which will allow establishing the perpetrator, and taking prompt measures on liquidation of the accident, pollution localization, and will inform about its size, speed of movement and the zone of influence.

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## REFERENCES

- [1] A. Kabata-Pendias and H. Pendias, "Trace Elements in the Biological Environment," Warsaw Yard Geology, Warsaw, 1979, p. 300.
- [2] L. K. Sadovnikova, "Heavy Metals—Soil Environmental Monitoring and Protection of Soils, Moscow State University Publishing House, Moscow, 1994, pp. 105-126.
- [3] V. V. Dyachenko, "Geochemistry, Systematics and Assessment of a Condition of Landscapes of the North Caucasus," Rostov-on-Don, Publishing Center "Kompleks", 2004, p. 268.
- [4] A. P. Vinogradov, "Geokhimiya of Infrequent and Dispersed Chemical Elements in Soils," Moscow, 1957, p. 157.
- [5] A. B. Ronov, A. A. Yaroshevsky and A. A. Migdisov, "Chemical Constitution of Crust and Geochemical Balance of the Main Elements," Nauka, Moscow, 1990, p. 182.
- [6] H. T. Shacklette and J. G. Boerngen, "Element Concentration in Soils and Other Surficial Materials of the Conterminous United States," Geological Survey Professional Paper (United States), 1984, p. 1270.
- [7] Yu. A. Malykhin, A. G. Malykhina and V. V. Dyachenko, "Medico-Ecological Researches Urbanized by Territories," Safety in a Technosphere, No. 3, 2008, pp. 16-21.
- [8] V. V. Dyachenko, I. Yu. Matasova and V. V. Rogovsky, "Problems of Technogenic Transformation of Landscapes of the Russian Black Sea Coast," Safety in a Technosphere, Moscow, No. 5. 2012, pp. 30-36.
- [9] V. V. Dyachenko, *et al.*, "Control of Aerosols in the Atmospheric Layer in the Real-Time," Safety in Technosphere, No. 3, 2008, pp. 36-43.