

Indicator of geoeological assessment of the region - population health

Stanislav Rodionov^{1,*}

¹Moscow State University of Civil Engineering, 26 Yaroslavskoye Shosse, 109377, Moscow, Russia

Abstract. The article shows that an effective indicator of the level of pollution of air, water and soil with toxic compounds of anthropogenic origin is a health of the population in different age groups. As eco-indicators, it is proposed to use diseases of the respiratory system for people under 18 years old, the circulatory and digestive systems - 18-56 years old, the musculoskeletal system - over 56 years old. To carry out ecological diagnostics of negative changes in the natural environment of urbanized areas of small towns, we propose to assess the response (reaction) – hospitalization rate in different age groups of the population: under 18 years old, 19-55 years old, and over 56 years old.

1 Introduction

The indicator and criteria for the environmental assessment of the Noginsky District of the Moscow Region is the change in the health status of the population. The impact of environmental factors correlates to human health, often causing a breakdown in the body's adaptation mechanisms.

2 Materials and methods

The issues of rational use of natural resources and environmental protection, regulation of the quality of the environment and the improvement of ways and methods are given great attention in the works of leading foreign and domestic scientists: A.G. Vetoshkin, V.A. Khabarov, B.I. Kochurov, S.N. Volkov, V.V. Vershinin, L.I. Egorenkov, V.A. Tolkachev, A.V. Khabarov, N.A. Yasamanov, W. Viscusi, and others.

3 Results and discussion

After ranking the urbanized areas taking into account the quality of the natural environment (air, water, soil), we found that the levels of environmental pollution for hazardous substances in the Noginsky district (Noginsk, Elektrostal, Elektrougli) exceed the permitted standards: in the air - benzo(a)pyrene (20-100 MPC) and nitrogen dioxide; in natural waters - nitrite and ammonium nitrogen, iron, manganese; in soils - chromium (6-8 MPC), lead (2-

* Corresponding author: RodionovSS@mgsu.ru

4 MPC), manganese, nickel (2-4 MPC), zinc, copper (2-4 MPC), cobalt (2-4 MPC), iron (above 10 MPC), etc. Powerful man-made (geochemical) flows affect the population health and the state of ecosystems in urban and rural settlements.

According to the prevalence of diseases in different groups of the population (Table 1), it can be said that in the first place in terms of the danger are diseases of the respiratory system and circulatory system (42.8% in the district as a whole, of which 43.3% are urban residents), in second place - diseases of the supporting and genitourinary system (14.9% in the district as a whole, of which 15.0% are urban residents).

Table 1. General structure of dispensary and health institutions attendance by residents of the Noginsky district by disease class (%).

Name of the disease	Population structure		
	District population	Urban residents	Rural residents
Respiratory diseases	28.7	29.1	25.9
Diseases of the circulatory system	15.1	14.2	21.3
Diseases of the musculoskeletal system and connective tissue	7.6	7.4	8.7
Diseases of the genitourinary system	7.3	7.6	5.2
Injury, poisoning and some other consequences of exposure to external causes	5.9	5.0	11.3
Diseases of the eye and its adnexa	5.5	6.1	1.6
Diseases of the skin and subcutaneous tissue	4.9	5.4	1.3
Mental and behavioral disorders	4.7	5.3	0.3
Diseases of the digestive system	4.6	4.2	7.3
Diseases of the nervous system	3.5	3.5	3.8
Some infectious and parasitic diseases	3.2	3.0	4.6
Endocrine system diseases, eating disorders and metabolic disorders	2.6	2.6	2.6
Neoplasms	2.4	2.6	1.3
Diseases of the ear and mastoid	2.2	2.4	1.1
Complications of pregnancy, childbirth and the postpartum period	0.8	0.7	2.0
Certain conditions arising in the perinatal period	0.4	0.4	0.8
Diseases of the blood, hematopoietic organs and certain disorders involving the immune mechanism	0.2	0.2	0.6
Symptoms, signs and abnormalities identified in clinical and laboratory studies, classified in other headings	0.2	0.2	---
Congenital anomalies (malformations), deformities and chromosomal abnormalities	0.2	0.1	0.3

Note that for the rural population, the second group includes the consequences of external causes (5.9% in the district as a whole, of which 11.3% are the rural population) and diseases of the digestive system (4.6% in the district as a whole, of which 7.3% rural population). This fact may be associated with both non-compliance with safety regulations and an increased risk associated with professional activities (agricultural work, etc.). In general, the incidence rate of urban residents from ecologically caused diseases prevails

over the incidence rate of rural residents of the region. In urban and rural settlements where a relatively satisfactory ecological situation is observed (Mamontovo, Akseno-Butyrskoye, Stepanovskoye, Bunkovskoye, Yamkinskoye), the incidence rate of residents is more evenly distributed by classes, which also gives grounds to conclude about the relationship between the diseases of the residents of the district and the state of the environment.

Analysis of the data on hospitalization of the population (Fig. 1, [1-2]) showed that the curve of the dependence of age on the level of hospitalization has peaks for the age groups of 18±4 and 56±4 years old. Therefore, we believe that for ecological diagnostics, this fact is important to take into account in the geoecological analysis of urbanized territories. We grouped information about the health of the population into three age groups - under 18 years old, 18-56 years old, and over 56 years old (Table 2). In terms of the hospitalization rate (per 1000 people) and the number of bed days (per 1000 people), the data for groups under 18 and over 56 years old are comparable for both urban and rural populations. In contrast, in the 18-56-year-old group, the rural population had an excess of 29% in the number of bed-days (per 1000 people) compared to the urban population, which can be explained by the increased risk associated with professional activity and insufficient level of service in medical institutions. The change in the dynamics of hospitalization for men in urban and rural settlements has the form of a descending curve, which coincides with the shape of the curve for women (Fig. 2) of the corresponding settlements. After approximating the data using a polynomial trend line, it was found that the reaction of men in the group of 18-56 years old and older than 56 years to negative environmental influences is less pronounced than that of women of the same age.

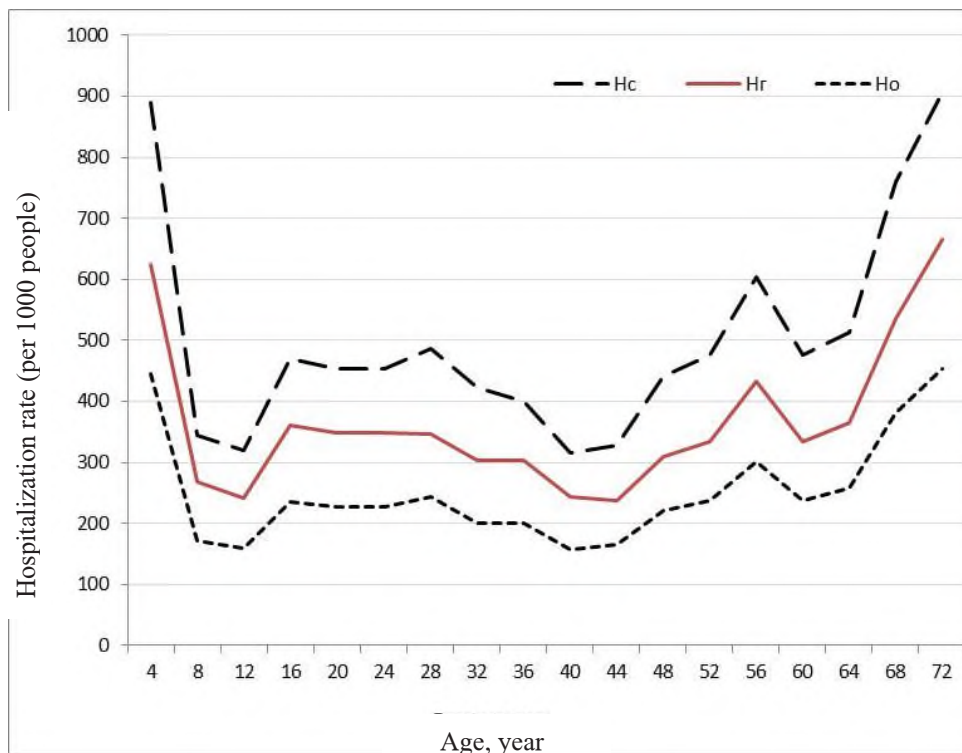


Fig. 1. Hospitalization rates of urban and rural residents per 1000 people of the corresponding population in the Noginsky district: Po – district population, Pu – urban and Pr – rural population.

Table 2. Age and sex indicators of hospitalization of urban and rural residents per 1000 people of the corresponding population.

Age groups	District population			Urban population			Rural population		
	Hospitalization rate (per 1000 people)	Average duration of inpatient treatment	Number of bed-days (per 1000 people)	Hospitalization rate (per 1000 people)	Average duration of inpatient treatment	Number of bed-days (per 1000 people)	Hospitalization rate (per 1000 people)	Average duration of inpatient treatment	Number of bed-days (per 1000 people)
under 18 years old	1011	63.8	7885.3	484.7	32.6	3915.4	526.3	31.2	3969.9
18-56 years old	1751	190.1	20942	800.7	90.5	9117.8	950.3	99.6	11824.2
over 56 years old	1090.3	84.1	15410.1	473.1	40.9	6463.6	617.2	43.2	8946.5
Total	3852.3	338	44237.4	1758.5	164	19496.8	2093.8	174	24740.6

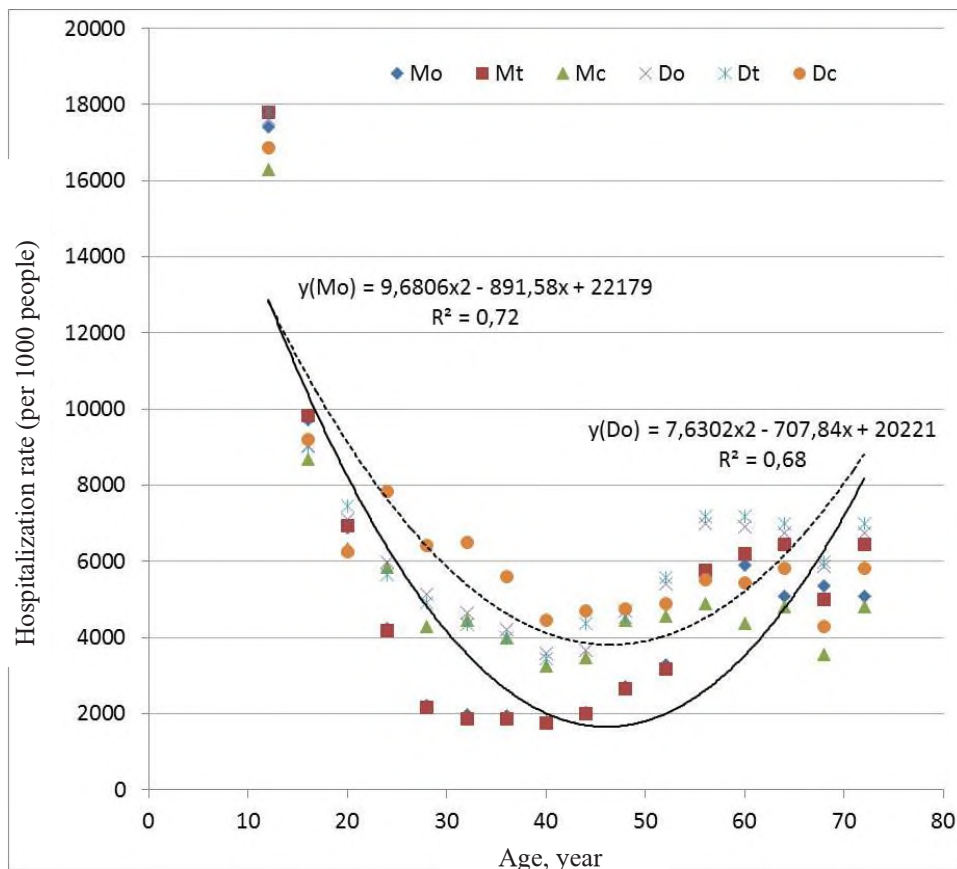


Fig. 2. Age and sex indicators of hospitalization of residents per 1000 people in the Noginsky district: Mo| Do – men and women in the district, Mt \ Dt – urban and Mc \ Dc – rural population.

The assessment of the health of population aged less than 18 years is of particular interest in the issue of ecological diagnostics of urbanized territories. The reaction to the negative impact of the natural environment in this age group is mainly manifested in the form of allergic diseases (diseases of the respiratory system) to particles of dust and soot, which are carriers of allergens and have a technogenic origin. In the Noginsky district, this type of disease ranks first among others - 29% of the total population suffers with it. Monitoring data (<http://zdravnoginsk.ru>) structured in Fig. 3 demonstrate that the residents of Noginsk, Staraya Kupavna, Elektrougli, and Elektrostal at the age of 18-56 mainly have respiratory and digestive diseases associated with the quality of drinking water (!) and/or food products. Diseases of the musculoskeletal system in residents of the age category “56 years old and older” are mainly manifested in the territory of Elektrougli, which is apparently associated with a high level of soil pollution, primarily with benzo(a)pyrene, nickel, copper, cobalt [5].

Noginsk	B	A,B,C	A,C
Staraya Kupavna	B	B,C	
Elektrougli		A,C	A
Elektrostal	B	A,B,C	A,C
	under 18 y.o.	19-64	over 65 y.o.

Fig. 3. Scheme of recorded chronic diseases in different age groups of the population (average for the period 2008-2010): A - diseases of the circulatory system and digestion; B - diseases of the respiratory and digestive organs; C - diseases of the musculoskeletal system.

For the neighboring Shchelkovo district [3], chronic diseases of the circulatory system were observed in all age groups. Shchelkovo occupies a leading place among the causes of death due to diseases of the circulatory system, arterial hypertension and coronary heart disease, and respiratory diseases due to high levels of air pollution, as well as urolithiasis due to drinking water pollution [2]. These data do not contradict the facts established by us.

Therefore, based on the identified dependencies of the population health status (type of disease) and negative changes in the natural environment (air, water, etc.), we propose to use the response (hospitalization rate) in different age groups (less than 18, 18 -56, and over 56 years old). Let us explain our suggestion: conditionally “natural” (or congenital) diseases for the age group “under 18 years old” can be considered diseases of the blood circulation, for the group “over 56 years old” - respiratory diseases. In the case when we observe the opposite reaction, for example, in the group “under 18 years old” - an increase in respiratory diseases (allergies), the elderly “over 56 years old” - circulatory diseases, then we can assume that this ecological situation in the settlements is critical.

Our proposed assessment of the incidence rate in different age and sex groups of urban and rural residents is also effective from the standpoint of an economic assessment of the environment quality. For example, an exacerbation of asthma in a group under 18 years old under the influence of negative factors of air pollution can be estimated by the parents' disability - for a period of 30-45 days - 250-1200 USD/year per 1 child. As a result, the economic damage can be considered comparable to the costs of medical treatment and payment of temporary disability sheets. It should be noted that the amount of money spent

will vary depending on the degree of the disease, the prescribed procedures, etc. And given the age specificity of the treatment of groups over 56 years old, the exacerbation of diseases of the musculoskeletal system may entail more significant economic damage.

As an indicator of the geoeological capacity of territories, we calculated the demographic tension index (DTI), which takes into account the density and incidence rate of the population [6-7].

$$DTI = U \cdot \lg \rho (0,1Z - 2B + M) \cdot CM2 \cdot \mu,$$

where U – degree of urbanization of the territory: the share of the area occupied by urban development, industrial facilities and communications (from 0 to 1); ρ – population density, people/km²; Z – total annual incidence of the population (per 1 000); B – birthrate (per 1 000); C – general mortality (per 1 000); CM – child mortality (per 1 000); $\mu = 10^{-4}$, scale factor at which DTI = 1.

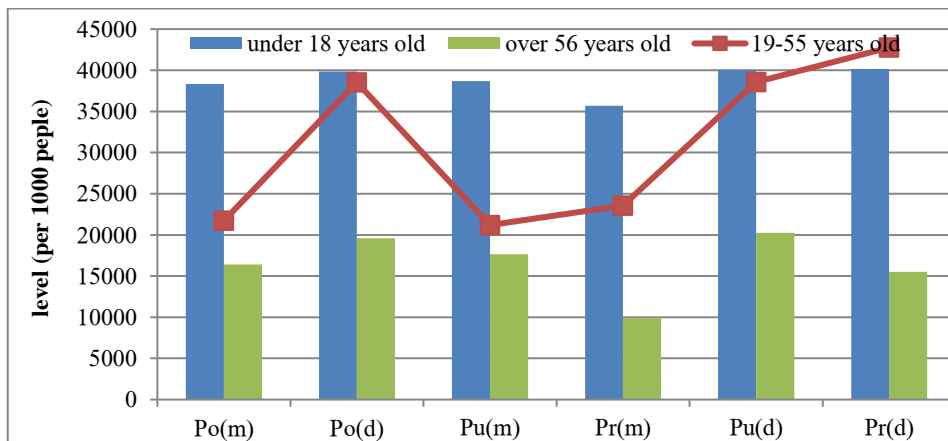
According to our calculations (Table 3), a number of the studied urbanized territories of the Noginsk district are characterized by powerful technogenic pollution, which affects the health of the population and the state of ecosystems in urban settlements (Noginsk, Elektrostal, Staraya Kupavna, Elektrougli DTI = 7.4 ± 4.2). In rural settlements (for example, Bunkovskoye), this indicator is much lower, which in general “improves” the DTI indicator for the entire Noginsky district.

Table 3. Characteristics of demographic tension in the settlements of the Noginsk district.

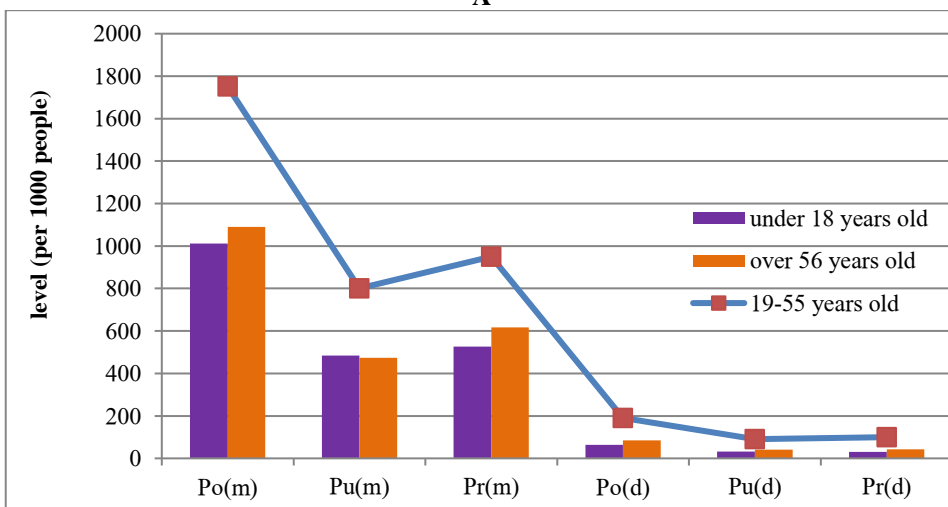
Indicators	Bunkovskoe	Noginsk	Elektrougli	Staraya Kupavna	Elektrostal	Noginsky district
Territory area, km ²	73.6	72.4	58.4	55.9	28.0	928
Including occupied by urban development, industrial facilities and communications, km ²	11.6	35	5.7	27.8	16	280.2
Population, thousand people	7.4	103	21.9	29.4	153	244
Population density, people/km ²	105	1953	4471	526.7	6 375	263
Total annual incidence (per 1 000)	1000	1150	1050	1100	1 520	1 012
Birthrate, % (per 1 000)	10	11	10.2	10.1	10.2	10.7
General mortality,% (per 1 000)	15	21	19	14	11.1	12.9
Child mortality,% (per 1 000)	14	12.5	10.3	13	18.8	17.2
DTI	1.7	11.7	9.9	9.0	10.7	1.4

Note: DTI = 7.4 ± 4.2 (mean value ± error).

It should be added that the hospitalization rate in the extreme age groups (“under 18” and “over 56 years old”) is comparable. We believe that the indicators for these groups can be used as indicators of the ecological state of the environment. Let us explain our suggestion: conditionally “natural” (or congenital) diseases for the age group “under 18 years old” can be considered circulatory diseases, for the elderly or “over 56 years old” - respiratory diseases. In the case when we observe the opposite reaction, for example, in the group of children - an increase in respiratory diseases (allergies), in the elderly - circulatory diseases, then we can assume that this ecological situation in the settlements is critical [8].



A



B

Fig. 4. Age and sex indicators of urban (Pu) and rural (Pr) population (based on the results of our own research).

Legend: (A) - attendance and (B) hospitalization of persons per year of the corresponding population male (m) and female (d), general (o), urban (u) and rural (r) population.

For the graphical presentation of cartographic materials, specialized graphic editors Adobe Photoshop, AutoCad and the GIS PANORAMA software complex, GoogleMap, YandexMap interactive electronic resources, etc. were used.

In our study, ecological mapping included the collection, analysis (of spatial and temporal variability) and vector representation of information on the state of the human environment. As a result, an analysis of the ecological situation of the urbanized territories of the Noginsky district, an assessment of the quality of the state of the air basin and water bodies was carried out, and environmental factors that negatively affect human health were identified [8-10].

4 Conclusions

Thus, the assessment of the health status of the population in different age groups showed the predominant manifestation of allergic diseases in the group “under 18 years old” in the urban settlements of Noginsk, Elektrostal, Staraya Kupavna, diseases of the musculoskeletal system - in the age group “over 56 years old” among residents of Noginsk, Staraya Kupavna, Elektrougley, Elektrostal. These indicators are effective as ecoindicators of a dangerous level of air, water and soil pollution by toxic compounds of technogenic origin.

In general, it was found that the ecological capacity of the urbanized territories of the Noginsky district in a number of settlements was exceeded by an order of magnitude (for example, the city of Elektrostal) compared with the average level for the district.

The analysis of the impact of environmental factors on the population health leads to the conclusion about the causal relationships between diseases of the systems of the organs of blood supply, respiration, digestion, as well as allergic reactions and the state of the environment. To carry out ecological diagnostics of negative changes in the natural environment of urbanized areas of small towns, we propose to assess the response (reaction) – hospitalization rate in different age groups of the population: “under 18 years old”, “19-55 years old”, and “over 56 years old”.

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