

**DETERMINED ECOLOGICAL HUMAN HEALTH RISK FACTORS IN SINGLE FACTORY TOWNS<sup>1</sup>****V. Boev<sup>1</sup>, M. Boev<sup>1</sup>, L. Tulina<sup>2</sup>, A. Neplokhov<sup>2</sup>**<sup>1</sup>State Budgetary Educational Institution of Higher Professional Education “Orenburg State Academy of Medicine”<sup>2</sup>Federal Budgetary Health Care Institution “The Orenburg Region Center for Hygiene and Epidemiology”

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**Abstract.** We have undertaken a comprehensive comparative assessment of quantitative relationships between the contribution of environmental anthropogenic factors and the indicators of individual and population carcinogenic and non-carcinogenic risks. This assessment confirms the influence of the major anthropogenic factors on children's health in single factory towns.

**Key words:** single factory town, individual and population carcinogenic risk, anthropogenic factors, children.

Negative trends in public health in Russia today develop from exposure to a number of environmental factors associated with the change in socioeconomic and medico-environmental living conditions [5, 6, 7]. Such changes are especially typical of small towns with one core industrial enterprise [3]. Almost 40 % of the total number of cities in Russia is comprised of small towns including, according to the Town Planning Code (2004), towns with the population of 20–50 thousand people which means that every fifth Russian citizen lives here. In Orenburg Region, 42.6 % of the population lives in rural areas (27 % of Russians live in rural areas); 58 % of urban areas are comprised of small towns.

Taking into account a wide range of public health and environmental assessment criteria, we included in the research procedure an integrated differentiated analysis of the environmental quality based on the identification of xenobiotics in the air, water and soil on the basis of own field observations and socioeconomic monitoring databases including an assessment of non-cancer and carcinogenic health risks in children [4, 8].

A negative impact of xenobiotics is reflected in all the natural environments since the main body of this agent falls on the ground being washed from the air in the form of precipitation accumulated in the accumulative environments. In order to decipher the region's ‘chain or reasons’ that determines the pathology of a specific population and find the chains that are easy to affect and thus remove unfavorable impact of risk factors, it is necessary to determine an objective connection between the level of environmental factors impact and the state of public health. At the same time, it is necessary to analyze the current negative trends in the environment from the position of integrated analysis of human-induced environmental factors using system analysis based on long-term socio-hygienic monitoring data.

The biggest air pollutants in the areas under study are: Gai Mining and Processing Works, Gai Non-Ferrous Metals Plant “Splav”; in Kuvandyk: South Urals Cryolite Plant, “Dolina” Machine Building Enterprise; in Mednogorsk: Mednogorsk Copper and Sulfur Plant; in Novotroitsk: Ural Steel, Novotroitsk Cement Plant, Novotroitsk Silicate Wall Material Plant, Novotroitsk Chrome Compounds Plant. We determined statistically significant differences in the levels of air pollution among the towns (Table 1). We identified the chemical elements with the

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concentrations that exceed the permissible level: suspended substances in Novotroitsk – by 2.2 times, in Gai – by 1.7 times; nitrogen dioxide in Mednogorsk and Kuvandyk – by 1.8 times, in Novotroitsk – by 1.3 times; sulfate dioxide in Mednogorsk – by 2.9 times. The total air pollution indicator in Novotroitsk was 1.28 times higher than in Mednogorsk, in Kuvandyk it was 1.74 times higher, and in Gai – 2.7 times higher. Additive effects in the summation groups exceeded the permissible level in most cities, including:

- sulfur dioxide + nitrogen dioxide in Mednogorsk – by 4.6 times, in Kuvandyk – by 2.6 times, in Novotroitsk – by 2.3 times, and in Gai – by 1.2 times.

- sulfur dioxide + hydrogen sulfide in Mednogorsk – by 3.2 times, in Novotroitsk – by 1.2 times.

Table 1

The level of air pollution in industrial cities in 2005–2010  
(in fractions of maximum permissible concentration)

Indicator	Novotroitsk	Mednogorsk	Kuvandyk	Gai
Sulfur dioxide	0,82±0,30	2,53±0,35*	0,63±0,17	0,13±0,02*
Nitrogen dioxide	1,37±0,06	1,68±0,07*	1,76±0,10*	1,06±0,01
Suspended substances	1,99±0,21	1,05±0,07*	1,15±0,06	1,72±0,15
Carbon monoxide	0,51±0,07	0,41±0,03	0,47±0,04	0,40±0,09
Hydrogen sulfide	0,27±0,03	0,31±0,03*	0,27±0,03	0,20±0,03
<b>To sum</b>	<b>4,94</b>	<b>3,86</b>	<b>2,84</b>	<b>1,83</b>
Sulfur dioxide + Nitrogen dioxide	2,18±0,30	4,2±0,38*	2,39±0,13	1,19±0,09
Sulfur dioxide + Hydrogen sulfide	1,08±0,31	2,84±0,37*	0,9±0,17	0,33±0,02

Note: \* – confidence level as compared to the mean regional value ( $p < 0,05$ ).

When comparing the level of pollution in individual cities with an average regional level, it was determined that in Novotroitsk, the concentration of sulfur dioxide is 2.5 higher ( $p < 0,001$ ); the concentration of nitrogen dioxide is 1.3 times higher in Kuvandyk ( $p < 0,01$ ), and in Mednogorsk it is 1.2 times higher ( $p < 0,001$ ). Despite the fact that sulfur dioxide in the cities of the region did not exceed the permissible level, its concentration in the air of Mednogorsk exceeded the average regional level by 1.2 times ( $p < 0,01$ ). The total air pollution indicator (to sum) in residential areas was 3.4 for single-plant cities.

In accordance with the research objectives, we conducted an analysis of the concentration of ferrum, nitrates, ammonia, sulfates, chlorides, fluoride, boron, manganese, arsenic, lead, chrome, copper, molybdenum, selenium, zinc, aluminum, the level of hardness and mineralization, and calculated the total indicator Kwat in drinking water in the residential areas of the regions' small towns with single nonferrous and ferrous metallurgy (Novotroitsk, Mednogorsk, Kuvandyk, and Gai). The results of a socio-hygienic monitoring for 2005–2010 showed that the single-plant towns under study have a high concentration of ferrum, chrome, manganese, arsenic, boron, and lead as well as a higher concentration of aluminum and selenium (Table 2).

Consequently, the qualitative characteristic of drinking water in small towns did not exceed the hygienic standards. At the same time, the total indicator analysis (Kwat) revealed a

higher concentration of chemical components in the drinking water of Novotroitsk, and the drinking water of Gai had the lowest indicator (Table 3).

Table 2

Characteristics of sanitary and hygienic parameters of the drinking water in urbanized areas of single-plant towns in 2005–2010 (M±m)

Parameter	Concentration, mg/l
Copper	0,04±0,007
Ferrum	0,22±0,07*
Chrome	0,007±0,001
Zinc	0,039±0,008*
Manganese	0,06±0,008*
Boron	0,13±0,014*
Fluoride	0,19±0,02*
Lead	0,005±0,001
Selenium	0,00026±0,00008
Aluminum	0,02±0,001
Arsenic	0,004±0,0006*
Molybdenum	0,0039±0,0007*
Ammonium	0,10±0,02*
Sulfates	151,4±11,3
Nitrates	12,4±1,1
Chlorides	145,5±8,2
Mineralization	661,5±25,8
Hardness, mg*eq/l	6,4±0,35
<b>Total indicator (Kwater)</b>	<b>5,7</b>

Note: \*P < 0,05

Table 3

Total indicator of the drinking water quality (Kwater)

Town	K water
Gai	3,7
Novotroitsk	4,7
Mednogorsk	4,4
Kuvandyk	4,2

Assessment of the human-induced impact in the towns under discussion for the period of 2005–2010 showed that in terms of human-induced impact on the air and hydrospace, the maximal impact was registered in Novotroitsk followed by Mednogorsk, Gail, and Kuvandyk.

Soil as an inherent part of the environment is the most important factor in the integrated human-induced impact on the condition of public health. It was determined that the metal pollution of soil is of local character and increases with proximity to stationary pollution sources [1,2]. For the purposes of the research, the quantitative characteristic of the soil pollution of the residential areas of single-plant towns was conducted on the basis of determination of the average concentrations of the chemicals in the soil and also by the total indicator (Ksoil) calculated in terms of gross and mobile forms of metal. Gross forms of elements in chemical compounds and the organic parts of the soil are non-mobile. Mobile forms of elements are known as the most reliable sources of information about environmental pollution.

For the purposes of the research, we conducted a comparative analysis of the concentrations of the elements under study in the soil of the residential areas of the region's

single-plant towns with the enterprises specialized in nonferrous and black metallurgy (Novotroitsk, Mednogorsk, Kuvandyk, and Gai). Our analysis of the pollution level in single-plant towns showed that mobile nickel forms have the highest concentrations (1.4 times higher) (Table 4), but at the same time, other elements under study did not exceed the maximal permissible concentration (MPC) (approximate permissible concentration APC).

Specifically, the highest total indicator was registered in Mednogorsk which exceeded the average regional indicator (K soil-4,9) by at least 2 times (Table 5).

Table 4  
Comparative characteristics of in the soil of residential areas of single-plant towns

Metals		Concentration (M ± m), mg/kg	Compared to MPC (APC)
Mobile form	Nickel	5,6±1,9	1,4
	Copper	2,2±1,03	0,7
	Zinc	10,64±1,18	0,5
	Lead	1,5±0,2	0,2
	Manganese	47,62±6,2	0,3
	Cobalt	1,6±0,2	0,3
	Chrome	0,9±0,09	0,1
<b>K mobile soil forms</b>			<b>3,64</b>

Table 5  
Total indicator of soil pollution in the residential areas of single-plant towns (Ksoil)

Town	Total indicator of soil pollution (K soil)
Mednogorsk	11,8
Kuvandyk	5,7
Novotroitsk	4,5
Gai	3,0
<b>Region</b>	<b>4,9</b>

The above analysis of the level of pollution of the residential areas in single-plant towns revealed the total impact including the constellation of air, soil, and water pollution and combined ways of entry into a human body. Table 6 shows that the absolute value of total human-induced impact in small towns includes air pollution (24.5 %), drinking water pollution (30.5 %), and soil pollution (55 %).

Table 6  
Total environmental pollution indicator in single-plant towns

Town	Air	Water	Mobile soil form	<b>K Integrated index</b>
Gai	1,83	3,7	3,0	8,5
Novotroitsk	4,94	4,7	4,5	14,1
Mednogorsk	3,86	4,4	11,8	20,1
Kuvandyk	2,84	4,2	5,7	12,7
<b>K town</b>	<b>3,4</b>	<b>4,25</b>	<b>6,25</b>	<b>13,9</b>

At the same time, taking into account a different number of factor-oriented assessments for different environments, we decided to calculate a graded indicator – hygienic grade that included the number of factors in the total pollution indicator of an environment under evaluation. With permissible level of impact, the indicator value must be ≤ 1.

Analysis of the urban areas showed that the highest hygienic grades in terms of chemical element concentration were determined for all environmental factors. The integrated index in all the environments exceeded permissible level. Assessment of a multi-component risk to children's health was conducted in terms of average indicators of the single-plant towns under study. We determined that in single-plant towns, copper (HQ = 6,6), sulfuric acid (HQ = 3,4), nitrogen dioxide (HQ = 1,54), sulfur dioxide (HQ = 1,49), and the sum of suspended substances (HQ = 2,9) were the biggest contributors to the development of non-carcinogenic effects, with the account for the assessed hazard index (index – HA) and total indices (HI).

Table 7

Total hazard indices for the critical body organs and systems

Total non-carcinogenic hazard index (HI)	Single-plant towns	
	Air	Water
Respiratory organs	14,54	–
Blood	0,20	0,02
Central nervous system	0,39	0,01
Immune system	0,20	0,003
Cardiovascular system	0,51	0,02
Reproductive system	–	–
Kidney	0,42	0,001
Hormone system	–	–
Systemic lesion	6,6	–
Total HI	22,86	0,054

When assessing the risk of non-carcinogenic effects on certain organs and systems that are frequent targets for pollutants, we calculated the total hazard indices (Table 7). We determined that in single-plant towns, the total non-carcinogenic risk to children's health from air pollutants by far exceeds that from drinking water pollutants. When assessing the risk of non-carcinogenic effects on certain organs, we determined that the biggest risk associated with a chemical impact on respiratory organs in small towns was presented by sulfuric acid (very high risk), hydrogen sulfide, sulfur dioxide, nitrogen dioxide, and suspended substances (average risk).

Table 8

Total individual (ICR) and population (PCR) carcinogenic risk to children's health

Carcinogens	Single-plant town	
	ICR	PCR
<i>Nickel</i>	2,76E-06	0,015
Lead	2,7E-06	0,015
Cadmium	1,09E-05	0,06
Chrome (6)	7,6E-05	0,4
benz(a)pyrene	1,0E-03	5,39
CR tot.	1,09E-03	5,9

The data in the above table shows that the total individual carcinogenic risk to public health in single-plant towns reaches the level of  $10^{-3}$  throughout the life and is considered high. The results show that in terms of non-carcinogenic effects development, single-plant towns with a total hazard index from air pollutants equal to 22.86 present the biggest risk to public health

adjusted for the calculated hazard index. The total carcinogenic individual risk to children's health in single-plant towns reaches the level of  $1.09 \cdot 10^{-3}$  throughout the life and is considered high. The obtained results show that single-plant towns are the most unfavorable in terms of development of non-carcinogenic and carcinogenic effects.

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