

# Integrated Assessment of Sanitary and Epidemiological Safety Management Efficiency of the Population in Industry – Based Cities in the Russian Federation

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**Abstract**— The article is devoted to the efficiency of management process of sanitary and epidemiological safety of people, living in Russian single-industry cities and towns for the period of 2014-2016. Comprehensive assessment of efficient management of sanitary and epidemiological safety of population is offered, that is understood as a comparison of economic benefits from environmental improving with value of population wellness upgrading. Estimation results of the main characteristics of sanitary and epidemiological safety of single-industry town residents in Russia such as the quality of atmospheric air, soil and water, different emissions and occupational illnesses are introduced. Data basis of the research characteristic values was taken from the statistics of Chelyabinsk region Department of Federal agency of supervision in consumer rights protection and human welfare in Magnitogorsk. The methods of economic analysis were used as the research tools. The research relevance is determined by the concern of physical condition and wellness of the population which is constantly being influenced with negative impact of the environment, large enterprises' activity, low –quality nutrition and natural resources, labour safety troubles. The research findings of the emissions in industry-based cities allow us to conclude that there is a real decrease in the amount of the pollutants from stationary resources in the industrial cities by 2,272 tons due to the taken environmental measures. According to the research, the major pollutant of the atmospheric air is benzopyrene, as well as suspended substances and ferrous oxide, but the leading sources of benzopyrene pollution are PSC –MMK”, JSC –MRK” and motor vehicles. For the improving of sanitary and epidemiological safety of industry-based town residents, the list of measures to bring the quality of tap water into accordance with the set requirements for the period from 2017 to 2022 is proposed. The forecasting of tap water quality improvement and water hardness reduction as well after water purification system setting within the research is based on the retrospective results of similar water purification systems implementation in municipalities of constituent territories of the Federation and probabilistic forecasting system. The carried out calculations have shown 7,039% as an average amount of tap-water quality increase. The research findings have practical relevance as they can be used to enhance the available programs in federal and regional levels in order to improve ecological environment.

**Keywords**— *Sanitary and epidemiological safety of population, atmospheric air pollution, tap water, a single-industry city, health care of population.*

## 1. INTRODUCTION

Health care of population is a combination of political, economic, legal, sanitary and epidemiological measures aimed at preserving and strengthening the moral and physical well-being of the population. In order to effectively manage the population well-being, it is necessary to comply with sanitary norms and regulations, as well as effectively monitor the state of all natural resources, human food and animal life, next to which a person exists. The well-being of a person depends directly on himself. Understanding of this ensures the desire of people to take control of all spheres of life and protect themselves from negative influence. For this purpose, sanitary and hygienic rules and regulations are developed, which are designed to protect the population as much as possible and get natural processes under control.

Sanitary and epidemiological monitoring, which is part of the authority of Federal Service for Surveillance on Consumer Rights Protection and Human Wellbeing, is an important element in monitoring the well-being of the population. Monitoring ensures the identification of factors that have a harmful effect on humans and their assessment, prediction of the health of the population and the human environment, the development of proposals for decision-making in the field of ensuring the sanitary and epidemiological welfare of the population, identifying measures to prevent and eliminate the impact of harmful habitat on human health. This allows effective monitoring the health indicators, the level and quality of population life, as well as responding immediately to revealed deviations.

The relevance of the study is due to the importance of the state of health and the quality of population life, which are subject to the constant influence of such factors as the negative impact of the environment, the functioning of large enterprises, of poor quality of nutrition and natural resources, and labor protection problems.

The aim of the study is to investigate the effectiveness of managing the sanitary and epidemiological well-being of the

population of Russia's mono cities by the example of Magnitogorsk. In order to achieve this aim, the authors set the task of a comprehensive study of sanitary and epidemiological population welfare in Magnitogorsk.

## 2. REVIEW

Issues of sanitary and epidemiological welfare of the population are widely covered both in Russian and in foreign literature.

Theoretical and methodological issues of the sanitary and epidemiological welfare of the population are considered in the works of Aksenova O.I. [1], Ivanov S.I., Bolshakov A.M. [2; 3], Maymulov V.G., Brico N.I. [4], Belyaev E.N. [5], Volkova N.A. [6], Melinichenko P.I., Tutelyan V.A., Onishchenko G.G., Gubernsky Yu.D. [7], Rakhmanin Yu.A., Lisitsyn Yu.P., Mazaev V.T. [8], Martinchik A.N. [9], Shaposhnikov A.A. [10], Butaev T.M., Reshetnikov A.V., Kucherenko V.Z. [11], Kuzmin V.B. [12], Koptyakova S.V., Savchenko I.Ya. [13], Zaitseva N.V. [14] et al.

Theoretical and methodological issues of quality of atmospheric air, soil and water, of the level of occupational morbidity, of emissions of pollutants are considered in the works of Alferova I.N. [15], Yakovenko N.V., Avaliani S.L. [16], Butorina N.N. [17], Onishchenko G.G. [18], etc.

The possibilities of using foreign experience of the sanitary and epidemiological welfare of the population in the Russian Federation are studied by such authors as Smolensky V.Yu. [19], Toporkov I.G., Leaves G.D. [20] Herbert R.D., Jaakkola J.J.K. [21] etc.

The information base for the study of performance indicators is provided by the documents of legislative authorities, regulatory legal acts of the Federal Service for Supervision of Consumer Rights Protection and Human Welfare of the Russian Federation [22; 23; 24; 25], as well as the data from the Office of the Federal Service for Supervision of Consumer Rights Protection and Human Welfare in the Chelyabinsk Region in Magnitogorsk for 2014 - 2016. [26]. Economic analysis and modeling methods were used as a research tool [27].

## 3. THEORETICAL

Sanitary-epidemiological state of the population well-being in RF single-industry cities is accepted to be investigated in the following directions:

- First, the state of the human environment and its impact on public health;
- Secondly, the state of the medical and demographic situation and the incidence of mass non-infectious diseases (poisonings) in connection with the harmful effects of environmental factors on human beings;
- Third, the level of occupational morbidity.

An assessment of the human environment state and its impact on public health presupposes the study of the cause-effect relationships between the health status of the population and the impact of human habitat factors on it in order to take measures for eliminating harmful effects on the population, as well as identifying priority groups of factors and associated

with their negative impact of basic health indicators of the population [27].

The actual direction of management for Magnitogorsk, which should be given special attention, is the hygiene of atmospheric air, soil and water. The main sources of pollution of the single-industry city atmosphere are ferrous metallurgy enterprises, enterprises for the production of building materials, as well as road and rail transport. However, for the period of 2014-2016 a decrease in the amount of pollutants emissions from stationary sources in Magnitogorsk for 2.272 thousand tons due to ongoing environmental protection measures.

Based on the results of studies conducted by the Office of the Federal Service for Supervision of Consumer Rights Protection and Human Welfare in the Chelyabinsk Region, in Magnitogorsk it was found that the leading air pollutant is benz pyrene, as well as suspended matter and iron oxide. The main air pollutants of benz pyrene are JSC "MMK", JSC "MRK" and motor transport; the main contribution to air pollution by suspended substances and iron oxide is made by JSC "MMK". Despite a set of ongoing measures aimed at reducing pollutant emissions into the atmosphere, the total annual emissions in Magnitogorsk in 2016 amounted to 227.7 thousand tons, 89.9% of which are the emissions from stationary sources. With these data on the main indicators of environmental protection, the mono town takes the tenth place in the rating of the most unfavorable cities of the Russian Federation.

Tap water supply of the municipal formation is carried out from four infiltration sources with groundwater intake, connected hydraulically with surface water bodies. There is no non-central water supply in the city. Disinfection of water at water intakes is done with liquid chlorine. All water intakes - Malo-Kizilsky, Verkhne-Kizilsky, Yanghelsky and Kuibassovsky have sanitary-epidemiological conclusions for the projects of sanitary protection zones. In 2016, compared to 2014 in Magnitogorsk, the share of water samples from sources of centralized water supply that did not meet hygienic standards for microbiological indicators increased from 0.6% to 0.8%. The share of water samples from underground sources of centralized water supply that did not meet hygienic standards for sanitary and chemical indicators increased in 2016 as compared to 2014 by 5.3 times.

Moreover, the length of the distribution network in Magnitogorsk is 933.396 km., and the percentage of worn-out water networks is 73.0%. The quality of water in the distribution network, according to the Office of the Federal Service for Supervision of Consumer Rights Protection and Human Welfare in the Chelyabinsk Region in Magnitogorsk, deteriorates in chemical composition, but the proportion of tap water samples that do not meet hygienic standards for sanitary and chemical indicators and microbiological indicators in 2016 is reduced compared with 2014.

Not compliance of tap water quality with hygienic requirements is established by iron, stiffness, manganese, color, turbidity. The reasons for this lack of compliance are the increasing pollution of surface and groundwater; use of

obsolete technological solutions for water treatment in conditions of deteriorating water quality; low sanitary and technical condition of some existing water supply networks, considerable wear and tear. In order to improve the quality of tap water supplied to the population, Magnitogorsk has developed an Investment Program in the field of water supply and sanitation of the MP "Vodokanal" Trust in Magnitogorsk for 2016 - 2018.

91.0% of multi-apartment residential buildings of the municipal entity are provided with hot water supply, which requires the operation of a closed hot water supply system. In 2016, within the framework of sanitary and hygienic monitoring, 61 samples of hot water were examined according to sanitary and chemical parameters, according to microbiological indices, by temperature. Samples that do not meet hygienic standards, sanitary and chemical indicators and microbiological indicators for the past three years have not been recorded. At the same time, the main problems in hot water supply systems are the wear of heating mains, which is 54.0%. In addition, on the territory of the municipality in 800 multi-apartment houses, the project did not initially envisage a circulation pipeline. During hours of minimal water consumption, hot water in the system cools down in the absence of circulation, which leads to a violation of sanitary requirements for the hot water parameter.

The study of the soil pollution level for the period 2014-2016 in Magnitogorsk in general, showed that the percentage of samples that did not meet sanitary and hygienic standards fell to 0, except for benz (a) pyrene, which percentage of deviations decreased from 85.7 to 16.4%.

Contaminated soil can become a source of secondary pollution of water bodies, groundwater, plant foods and animal feeds and, thereby, affect the sanitary and hygienic situation as a whole. The city's sanitary cleaning system is planned and circular, however, and even under such a system, the management of the municipal entity faces problems in cleaning the territories from domestic waste: not timely harvesting and removal of solid household waste from garden non-profit partnerships; the lack of a monitoring system for the collection and removal of sewage from private households.

#### Proposals and results of experimental studies

In order to improve the sanitary and epidemiological safety of the population in single-industry cities, a plan of measures is proposed to bring the quality of tap water in accordance with the established requirements for the period from 2017 to 2022 given in Table I.

The proposed measures will help improve the quality of water in the territory of the municipal formation, thereby improving the quality of life and preserving the health of the population.

In order to increase the validity of proposed recommendations for the achievement of quality indicators of tap water in some wells of Yangelsk intake and bringing them into compliance with regulatory requirements, specialists should follow these steps: to predict the improvement of the quality of tap water by installing water purification systems at Yangelsk tap water intake. Prediction of improving the quality

of tap water, including the reduction of the total hardness, as a result of the installation of tap water purification system was based on the results of the retrospective implementation of similar tap water treatment systems in the municipalities of the Chelyabinsk region, presented in Table II, and the system of probabilistic forecasting.

TABLE I. Plan of measures to bring the quality of tap water in Magnitogorsk in accordance with the established requirements for the period from 2017 to 2022.

№	Action item	Timeline	Expectations
1	Reconstruction of the chlorine farm of the Upper-Kisil water intake, the transition to electrolysis purification.	2017	Exclusion from the technological disinfection process of tap water dangerous to the environment reagent-liquid chlorine and its replacement by safe sodium hypochlorite. The use of sodium hypochlorite instead of liquid chlorine leads to a reduction in side effects from the use of chlorine, namely: chloramines, trihalomethanes are not formed, organoleptic parameters are improved.
2	Installation for water iron removal on the Upper Kizil drinking water intake.	2017-2019	Reducing the iron content in the wells of Verkhne-Kisilsky water intake to the normative one.
3	Reconstruction and modernization of the main water pipeline.	2017-2021	Replacement of steel pipes with polyethylene ones and replacement of diameter 700mm by 500mm due to optimization of the hydraulic regime.
4	The tap water purification system of the Yanghel tap water intake.	2019-2022	Achieving quality indicators on the general rigidity in some wells of the Yangel water intake in accordance with regulatory requirements.

**TABLE II.** Introduction results of tap water purification systems in the municipalities of the Chelyabinsk region

Municipality name	Improving the quality of tap water as a result of the introduction of tap water purification systems, %
Verhneufalei urban district	6,4
Karabash urban district	7,1
Chebarkul urban district	5,0
Asha municipal district	5,0
Etkul municipal district	8,2
Katav-Ivanovsk municipal district	10,0

The system of probability forecasting is used to plan values that smoothly change in different directions, and is implemented in the MS Excel environment, which allows to significantly reduce the number of calculations. The system of probabilistic forecasting assumes the fulfilment of calculations in the following sequence:

1. The average expected value of the event is calculated by the formula (1):

$$\bar{x} = \sum_{i=1}^n p_i \times x_i \quad (1)$$

where  $p_i$  is the absolute value of the  $i$ - result;  $x_i$  is the probability of occurrence of the  $i$ - result;  $n$  is the variants number of the events outcome.

2. Mean square deviation of actual results from the average expected value, calculated by the formula (2):

$$\sigma = \sqrt{\frac{\sum_{i=1}^n (x_i - \bar{x})^2 \times n}{\sum n}} \quad (2)$$

The results of calculating the average expected value and the standard deviation are shown in Table III.

**Table III.** Results of probabilistic planning of tap water quality improvement

Reducing the rigidity of tap water as a result of installing a tap water purification system	Probability	Average expected value increase in tap water quality	The mean square deviation of the actual results from the average expected value, %
6,4	0,17	1,088	0,007
7,1	0,17	1,207	0,001
5,0	0,33	1,65	1,37
8,2	0,17	1,394	0,23
10,0	0,17	1,7	1,49
Eventual outcome	1,0	7,039	+/- 1,76

According to the table, the average expected value of tap water quality improvement is 7.039%. However, there are two possible scenarios:

1) optimistic, at which the increase in the quality of tap water can amount to 8.799% (7.039 + 1.76);

2) pessimistic, in which the increase in the quality of tap water can reach 5,279% (7,039-1,76).

#### 4. CONCLUSIONS

Thus, the proposed event related to the use of new tap water purification systems is effective, since it will significantly reduce the overall rigidity of tap water, which will lead to an increase in the quality of tap water and bring it in line with the established standards of sanitary regulations.

The results of the research are of practical importance, since they can be used to improve existing programs at the federal and regional levels in order to improve the environmental situation.

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