The Differentiated Approach to Assessment Individual Risk of Emergency

Ulyana S. Ivanova[1,2], Daria A. Chernykh[1,3], Olga V. Taseiko[1,3], Tatiana N. Nikulina[2]

[1] Institute of computational technological SB RAS, Krasnoyarsk, Russia, krasn@ict.nsc.ru
[2] Siberian Federal University, Krasnoyarsk, Russia, office@sfu-kras.ru
[3]Siberian State Aerospace University named after academician M.F. Reshetnev, Krasnoyarsk, Russia, info@sibsau.ru

Abstract. The problem of sustainable development of industrial areas on the basis of risk-based approach is considered. The purpose of the work is the analysis of methodological recommendations for the assessment of individual risk of emergencies. The relevance is determined by the need to implement the national safety strategy at the regional level on the basis development methods of technogenic safety analysis. In the conditions of the existing risk and negative consequences the organization and modernization of the territorial risk management system is necessary. The result is a ranking of Krasnoyarsk territories the level of technological risk (high, borderline, safe) with the use of a differentiated coefficient.

Keywords: safety, sustainable development, risk level, individual risks of emergencies

1 Introduction

To assess territory safety development and using of measures and methods of the risk analysis are prioritized. Support of people's life and society is given the most attention. At the present time scientific and organizational activities are being carried out to lower risk of accident and reduce the loss in emergencies as well [1-4]. The purpose of the work is to analyse of methodical recommendations to assess individual risk of emergencies.

Relevance is determined by the necessity for realize national safety strategy on regional level using methods of technogenic risk analysis.

There are the following tasks:

- calculation and analysis of individual risks of technogenic emergencies, using Krasnoyarsk territory as an example as within approved methodology;
- introduce differentiated coefficient to assess risk into the methodology;
- recalculation individual risk of emergencies.

2 The analysis assessment individual risk emergencies method

The official methodology to assess individual risk of emergencies is "The methodological recommendation for development, check, assessment and correction of territory electronic passport (object)" (Validate by Ministry of Emergency Russia 15.07.2016 № 2-4-71-40).

While identifying the risk of emergencies initial data is:

- general information about subject of Russian Federation (municipality);
- number and density population;
- character of area;
- information about assessment possible emergencies consequence.

The statistical indicators for risk are considered. Expected influence of risk is assessed on considered territory or object of economy.

Individual risk calculation is made to determine real level of risk (acceptable risk $R < 10^{-5}$) to identify necessary activites to rule and lower it. Individual risk of emergencies within the formule:

$$R = \frac{N_{\text{П}}}{N_{\text{Н}}} \tag{1}$$

where $N_{\text{П}}$ – mean of fatality (within year) in specific type of emergency on considered territory;
$N_{\text{Н}}$ – the number of population living there.

The individual risk of emergencies calculation has been made on example of Krasnoyarsk territory using statistical information official data Ministry of Emergency Russia and the methodological recommendations [5]. The Krasnoyarsk territory is industrial developed subject in Russia in Siberia Federal district, which is exposed to technogenic dangers:

- radioactive substances emission;
- chemical emission;
- destroying hydrotechnical construction and flooding;
- large industrial accident and fires;
- large car, rail and air accidents;
- disasters (forest fires, floods, earthquake) and other.

There are the following administrative units in Krasnoyarsk territory: 13 cities, 3 closed administrative-territorial entities (CATE), 44 municipalities and 1 urban-type locality (utl) [6]. The ranging of Krasnoyarsk territory (along individual risk level) has been presented on figure 1 (mean within 20 years). The value diapason (from 0 to $2 \cdot 10^{-4}$) has been gotten for municipalities from technogenic emergencies. Bogotolskij, Bolsheulujskij, Kozulskij, Manskij, Turuhanskij and Evenkijskij rigions of Krasnoyarsk territory are the most dangerous (individual risk values are higher than acceptable more then 10 time).

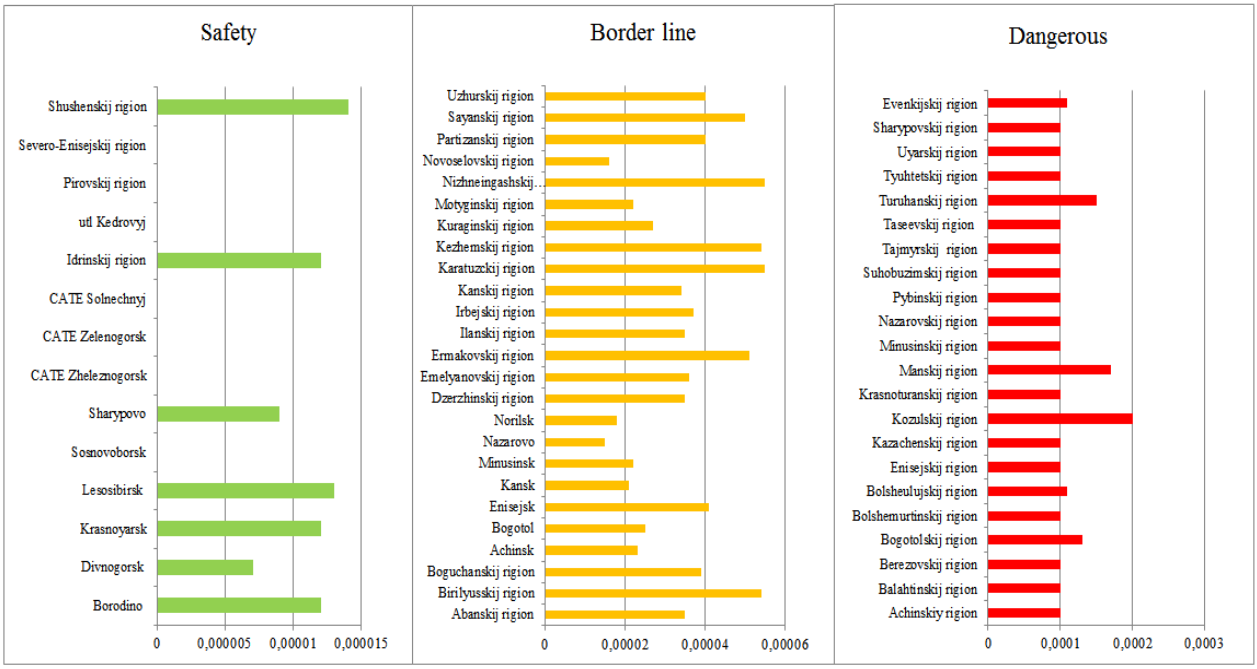

Figure 1. Ranging of municipalities along risk level.

The calculation values show 14 municipalities, which not higher than acceptable ones. It is mainly associated with lower number population on consideration area. So, the differentiation approach to assess individual risk is necessary, by introduction coefficient *k*. The acceptable level risk equals $1 \cdot 10^{-5}$ that compered fatality one human at one hundred thousand population. However, there are territories where the number of population is lower or a lot time higher this value. The introduced coefficient *k* will allow the more exact to identify and analyze dangerous level of territory more.

The coefficient is identified in two ways: The coefficient is identified: when $N \leq 100000$ and $N > 100000$. The values for first one are presented in table 1. For second event, the coefficient calculated along formula:

$$k = \frac{N}{100000}, \tag{2}$$

where N – number of population on looking territory higher 100000.

The source values and recalculated values of risk have presented in table 2 as well as it has done ranging across dangerous levels.

Table 1. The value of coefficient within number population lower 100000

Number population	Coefficient *k*
1-20000	0,1
20000-30000	0,2
30000-40000	0,3
40000-50000	0,4
50000-60000	0,5
60000-70000	0,6
70000-80000	0,7
80000-90000	0,8
90000-100000	0,9

Table 2. The differenced ranging of Krasnoyarsk territory

Rigion	Individual risk (*R*)	Number population [7]	*k*	Recalculated values of risk (*R*')	Acceptable risk	Ранжирование территорий
Abanskij rigion	$3,5\cdot10^{-5}$	19951	0,1	$3,5\cdot10^{-6}$	$1\cdot10^{-5}$	safety
Achinskiy rigion	$1\cdot10^{-4}$	15213	0,1	$1\cdot10^{-5}$		safety
Balahtinskij rigion	$1\cdot10^{-4}$	18664	0,1	$1\cdot10^{-5}$		safety
Berezovskij rigion	$1\cdot10^{-4}$	41727	0,4	$4\cdot10^{-5}$		border line
Birilyusskij rigion	$5,4\cdot10^{-5}$	9649	0,1	$5,4\cdot10^{-6}$		safety
Bogotolskij rigion	$1,3\cdot10^{-4}$	9751	0,1	$1,3\cdot10^{-5}$		safety
Boguchanskij rigion	$3,9\cdot10^{-5}$	45525	0,4	$1,6\cdot10^{-5}$		border line
Bolshemurtinskij rigion	$1\cdot10^{-4}$	18243	0,1	$1\cdot10^{-5}$		safety
Bolsheulujskij rigion	$1,1\cdot10^{-4}$	7525	0,1	$1,1\cdot10^{-5}$		safety
Achinsk	$2,3\cdot10^{-5}$	106531	1,06	$2,4\cdot10^{-5}$		border line
Bogotol	$2,5\cdot10^{-5}$	20020	0,2	$5\cdot10^{-6}$		safety
Borodino	$1,2\cdot10^{-5}$	16127	0,1	$1,2\cdot10^{-6}$		safety
Divnogorsk	$7\cdot10^{-6}$	33490	0,3	$2,1\cdot10^{-6}$		safety
Enisejsk	$4,1\cdot10^{-5}$	17826	0,1	$4,1\cdot10^{-6}$		safety
Kansk	$2,1\cdot10^{-5}$	89508	0,8	$1,7\cdot10^{-5}$		border line
Krasnoyarsk	$1,2\cdot10^{-5}$	1091634	10,9	$1,3\cdot10^{-4}$		dangerous
Lesosibirsk	$1,3\cdot10^{-5}$	64323	0,6	$7,8\cdot10^{-6}$		safety
Minusinsk	$2,2\cdot10^{-5}$	70910	0,7	$1,5\cdot10^{-5}$		border line
Nazarovo	$1,5\cdot10^{-5}$	49991	0,4	$6\cdot10^{-6}$		safety
Norilsk	$1,8\cdot10^{-5}$	180239	1,8	$3,2\cdot10^{-5}$		border line
Sosnovoborsk	0	40128	0,4	0		safety
Sharypovo	$9\cdot10^{-6}$	46603	0,4	$3,6\cdot10^{-6}$		safety

Dzerzhinskij rigion	$3,5 \cdot 10^{-5}$	13254	0,1	$3,5 \cdot 10^{-6}$		safety
Emelyanovskij rigion	$3,6 \cdot 10^{-5}$	50799	0,5	$1,8 \cdot 10^{-5}$		border line
Enisejskij rigion	$1 \cdot 10^{-4}$	22828	0,2	$2 \cdot 10^{-5}$	$1 \cdot 10^{-5}$	border line
Ermakovskij rigion	$5,1 \cdot 10^{-5}$	19334	0,1	$5,1 \cdot 10^{-6}$		safety
CATE Zheleznogorsk	0	92851	0,9	0		safety
CATE Zelenogorsk	0	62245	0,6	0		safety
CATE Solnechnyj	0	9950	0,1	0		safety
Idrinskij rigion	$1,2 \cdot 10^{-5}$	11183	0,1	$1,2 \cdot 10^{-6}$		safety
Ilanskij rigion	$3,5 \cdot 10^{-5}$	23806	0,2	$7 \cdot 10^{-6}$		safety
Irbejskij rigion	$3,7 \cdot 10^{-5}$	15 468	0,1	$3,7 \cdot 10^{-6}$		safety
Kazachenskij rigion	$1 \cdot 10^{-4}$	9643	0,1	$1 \cdot 10^{-5}$		safety
Kanskij rigion	$3,4 \cdot 10^{-5}$	25316	0,2	$6,8 \cdot 10^{-6}$		safety
Karatuzckij rigion	$5,5 \cdot 10^{-5}$	14950	0,1	$5,5 \cdot 10^{-6}$		safety
Kezhemskij rigion	$5,4 \cdot 10^{-5}$	20674	0,2	$1,1 \cdot 10^{-5}$		safety
Kozulskij rigion	$2 \cdot 10^{-4}$	16246	0,1	$2 \cdot 10^{-5}$		border line
Krasnoturanskij rigion	$1 \cdot 10^{-4}$	14067	0,1	$1 \cdot 10^{-5}$		safety
Kuraginskij rigion	$2,7 \cdot 10^{-5}$	44977	0,4	$1,1 \cdot 10^{-5}$		safety
Manskij rigion	$1,7 \cdot 10^{-4}$	15668	0,1	$1,7 \cdot 10^{-5}$		border line
Minusinskij rigion	$1 \cdot 10^{-4}$	25944	0,2	$2 \cdot 10^{-5}$		border line
Motyginskij rigion	$2,2 \cdot 10^{-5}$	13891	0,1	$2,2 \cdot 10^{-6}$		safety
Nazarovskij rigion	$1 \cdot 10^{-4}$	22063	0,2	$2 \cdot 10^{-5}$		border line
Nizhneingashskij rigion	$5,5 \cdot 10^{-5}$	29422	0,2	$1,1 \cdot 10^{-5}$		safety
Novoselovskij rigion	$1,6 \cdot 10^{-5}$	12969	0,1	$1,6 \cdot 10^{-6}$		safety
utl Kedrovyj	0	5450	0,1	0		safety
Partizanskij rigion	$4 \cdot 10^{-5}$	9283	0,1	$4 \cdot 10^{-6}$		safety
Pirovskij rigion	0	6867	0,1	0		safety
Pybinskij rigion	$1 \cdot 10^{-4}$	30943	0,3	$3,1 \cdot 10^{-5}$		border line
Sayanskij rigion	$5 \cdot 10^{-5}$	10746	0,1	$5 \cdot 10^{-6}$		safety
Severo-Enisejskij rigion	0	11090	0,1	0		safety
Suhobuzimskij rigion	$1 \cdot 10^{-4}$	20064	0,2	$2 \cdot 10^{-5}$		border line

Tajmyrskij region	$1 \cdot 10^{-4}$	31762	0,3	$3 \cdot 10^{-5}$		border line

Taseevskij region	$1 \cdot 10^{-4}$	11508	0,1	$1 \cdot 10^{-5}$	$1 \cdot 10^{-5}$	safety
Turuhanskij region	$1,5 \cdot 10^{-4}$	15971	0,1	$1,5 \cdot 10^{-5}$		border line
Tyuhtetskij region	$1 \cdot 10^{-4}$	8077	0,1	$1 \cdot 10^{-5}$		safety
Uzhurskij region	$4 \cdot 10^{-5}$	31408	0,3	$1,2 \cdot 10^{-5}$		safety
Uyarskij region	$1 \cdot 10^{-4}$	20715	0,2	$2 \cdot 10^{-5}$		border line
Sharypovskij region	$1 \cdot 10^{-4}$	14176	0,1	$1 \cdot 10^{-5}$		safety
Shushenskij region	$1,4 \cdot 10^{-5}$	32164	0,3	$4,2 \cdot 10^{-6}$		safety
Evenkijskij region	$1,1 \cdot 10^{-4}$	15147	0,1	$1,1 \cdot 10^{-5}$		safety

The values range of individual risk by technogenic emergencies have been gotten by recalculating within from 0 to $1,3 \cdot 10^{-4}$. The Municipalities have been presented on figure 2 in which values of individual risk are higher acceptable ones. Krasnoyarsk city has the highest of individual risk which equals $1,3 \cdot 10^{-4}$. This indicator is conditioned large quantities of potentially hazardous objects, critical and strategically infrastructure.

Figure 2. The municipalities of Krasnoyarsk territory with higher level individual risk.

Conclusion. To control anthropogenic safety is connected with predicting probable risks and develop in models and methods of technogenic risk analyses and assessment. There are the following results of this work:

- analysis of methodological recommendation for the assessment of individual risk of emergencies is done;
- calculation and the analysis of individual risk of emergencies for the Krasnoyarsk territory are made;
- individual risk recalculation is made (with the use of differentiated coefficient).

The analysis of territory technogenic hazard shows the large cities with developed infrastructure and dangerous object are exposed to the risk the most.

The reported study was funded by Russian Foundation for Basic Research, Government of Krasnoyarsk Territory, Krasnoyarsk Regional Fund of Science, to the research project No 18-47-240006: «Methods and information technologies for risk assessment of the development of socio-natural-technogenic systems in an industrial region».

References

[1] Makhutov N.A., Gadenin M.M. Environmental safety and environmental heritage in national security issues // Ecology and industry of Russia. 2016. Vol. 20. №3. P. 47-51.

[2] Safety of Russia. Legal, socio-economic, scientific and technical aspects. Regional safety issues. Krasnoyarsk territory, Moscow: Znanie, 2001. – 576 p.

[3] Moskvichev V. V., Bychkov, I. V., Potapov V. P., Taseiko O. V., Shokin Yu. I. Information system for territorial risk management development and safety // Bulletin of the Russian Academy of Sciences. 2017. № 8. P. 696-705.

[4] Safety of Russia. Legal, socio-economic, scientific and technical aspects. System studies of emergency situations. Moscow. "Knowledge", 2015. – 864 p.

[5] The methodological recommendation for development, check, assessment and correction of territory electronic passport (object) (Validate by Ministry of Emergency Russia 15.07.2016 № 2-4-71-40).

[6] On the protection state of population and territories for Krasnoyarsk territory from natural and man-made emergencies: State report. – Moscow: Ministry of Emergency Russia, 1996-2016 years.

[7] http://www.krskstate.ru/msu/terdel [Electronic resource] (accessed 18.06.2009).