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DETERMINATION OF TRENDS AND REGULARITIES OF OCCURRENCE OF EMERGENCY SITUATIONS OF TECHNOGENIC AND NATURAL CHARACTER IN UKRAINE

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ВИЗНАЧЕННЯ ТЕНДЕНЦІЙ І ЗАКОНОМІРНОСТЕЙ ВИНИКНЕННЯ НАДЗВИЧАЙНИХ СИТУАЦІЙ ТЕХНОГЕННОГО Й ПРИРОДНОГО ХАРАКТЕРУ В УКРАЇНІ

Purpose. Identification of trends and patterns of emergencies in Ukraine for their further forecasting and prevention.

Methodology. It was based on the system analysis of natural and man-made emergencies, with the estimation and forecasting of the frequency of their occurrence, based on the use of statistical analysis of dynamic rows and the construction of their trends.

Findings. It is established that the number of technogenic emergency situations in Ukraine is 1.5 times higher than the natural one. Meteorological emergencies are at the first place among all the subclasses of natural emergencies – an average 22.1 % of cases annually, the second place is associated with fires in natural ecological systems (10.8 % of cases), and there are geological and hydrological emergencies at the third place (5.0 and 5.1 % respectively). It is determined that each technogenic emergency situation incurs losses of 0.45 ± 0.17 million UAH, and each emergency situation of natural character on the average leads to losses at the level of 42.97 ± 23.97 million UAH. It is proved that 97.83 % of material damage to the economy of the state is caused by nature disasters, and the rest – by technogenic emergency situations, the specific losses from the last one tend to grow.

Originality. For the first time, on the basis of analytical studies, it has been established that there is a close growing linear relationship between the number of natural disasters and number of technogenic emergency situations, which is described by the equation $y = 1.3x + 18.34$ ($R^2 = 0.7763$). For each negative situation of natural origin with a fairly high reliability, there is 1.3 negative event of technogenic origin.

Practical value. The results of the study can be used to develop forecasts and take appropriate decisions on the prevention and elimination of emergencies.

Keywords: *emergency situation, accident, technogenic risk, ecological safety*

Formulation of the problem. In the industrial regions of Ukraine, the structure of nature use was formed over a long period of time, without considering objective laws for the development and restoration of natural resource complexes and ecosystems [1]. In addition, in these territories, the development of environmentally hazardous resource-extracting and processing industries was favored, leading to a high level of pollution of the atmosphere, underground and surface waters, and the accumulation of significant volumes of hazardous, including toxic and radioactive waste products [2]. As a result, in the early 1990s, the ecosystem and population health deteriorated dramatically, birth rates decreased, mortality increased, resulting in a negative population growth [1–3].

Industrial regions are one of the main factors of unsatisfactory ecological condition of Ukraine, since their share in the total volume of emissions and discharges of pollutants, as well as the volume of waste generation is 70–90 %. Significant anthropogenic and technogenic overload of the territory of Ukraine, as well as increased

risks of man-made and natural emergencies, constitute a threat to Ukraine's national security [4].

Ukraine occupies one of the first places in Europe in terms of the level of technogenic pressure on the environment. The main reasons for this situation are the high proportion of resource-intensive and energy-intensive technologies, implementation and expansion of which was carried out without considering the requirements of environmental protection and mechanisms for ensuring balanced use of nature [5].

The development of mining, fuel and energy, metallurgical, chemical and other ecologically dangerous industries has led to significant degradation of the environment, excessive pollution of the air, land, surface and groundwater, as well as the accumulation of a significant number of harmful, including highly toxic, industrial waste [6]. The high level of concentration of environmentally hazardous industries, the lack of proper environmental protection systems, as well as outdated production and equipment technologies lead to a sharp deterioration in people's health, a decrease in fertility and an increase in mortality rates threatening Ukraine's sustainable development.

A significant load of the territory of Ukraine with powerful industrial and energy facilities (according to the State Service of Ukraine, 9424 high-risk objects was functionated in Ukraine in 2014), increases the risk of accidents, the losses of which can be compared with the size of the national budget of the average country. And the presence in Ukraine of significant territories with unfavorable natural influences and propensity to manifestations of dangerous natural phenomena increases the acuteness of the problem of studying the state of technogenic and natural safety and the need to find ways to improve it [7, 8].

Such developments point to the inadequate efficiency of the existing state governance system for the state of the environment both at the regional and national levels [8, 9]. The need to improve the quality management of the environment is also conditional on the state's duty to implement the provisions of the Constitution of Ukraine on ensuring a healthy living environment for citizens.

Implementation of organizational, economic, engineering, and other measures to reduce the risks of emergencies to acceptable levels was declared one of the main directions of the state policy on national security issues. Therefore, the problem of increasing the efficiency of state and regional management of the state of the environment is extremely relevant and determines the choice of research topic.

Statement of an unsolved problem. The nature and scale of natural and man-made threats to the natural security of any country shows that its level can not be sufficient if the task of protecting the population, objects of economy, national heritage from emergency of any nature will not be solved at state level. A clear understanding of this fact determines the need for development of management measures, the essence of which is to create a holistic system of protection of people and territories from emergencies of technogenic and natural character and conduct a well-conspired policy on these issues internationally.

The formation of the national security strategy of Ukraine envisages the creation of an effective system for the identification, assessment and forecasting of the causes and consequences of emergencies [8, 10]. Ensuring the effective functioning of a unified state system of protection of the population, territories, objects of environment and property in emergencies by preventing and eliminating their consequences, as well as assisting the victims, is a very topical task.

One of the measures aimed at the effective implementation of state policy in the field of protecting population and territories from emergencies of technogenic and natural character is the study of trends and patterns of emergencies in territories with different levels of anthropogenic load. This will prevent the emergence of local and global ecological disasters and will ensure the preservation of natural resources as well as the restoration of mechanisms for self-regulation of ecological systems.

Analysis of recent research and publications. The works of leading scientists – O. M. Adamenko, G. O. Bilyavsky, O. I. Bondara, B. M. Danylyshina, S. I. Doroguntsova, A. G. Shapara, G. I. Rudka, A. B. Kaczynski, V. M. Isaenko and others are devoted to decision of the problem of analysis, forecasting and prevention of emergencies in Ukraine. These researchers pay attention to the environmental and technogenic consequences of the operation of enterprises in certain industries. However, in most cases, the complexity of the negative impact of a significant number of industrial enterprises located in confined areas is not taken into account. At the same time, a significant proportion of the equipment and technology used in these enterprises is morally and technically obsolete and worn-out, and this is also the reason for large-scale accidents.

Previous scientific researches were based on the study of economic, legal and technological aspects, but the use of geospatial assessment and forecasting of natural and technological safety, taking into account the principles of territorial distribution of dangerous natural phenomena and processes, as well as the placement of potentially hazardous economic objects [12] is insufficient. Particular attention should be also paid to nanomaterials, which are currently widely used in various industries [13].

Study of the frequency of emergencies and dangerous events and the identification of their most characteristic trends and patterns in order to further forecast and improve the system of protection of people and territories from emergencies is an important task, the solution of which becomes very relevant.

That is why it is necessary to take into account theoretical and methodological principles of humanitarian, social, economic and environmental factors of technogenic safety. This will allow for a comprehensive and integrated analysis of the existing state of technogenic and natural safety and ensure forecasting of environmental changes in the long-term dynamics.

Formulating the purpose of the work. The purpose of the work is to analyze the causes and consequences of emergencies of techogenic and natural disasters on the

territory of Ukraine and develop recommendations for their prevention.

Statement of the main material. To analyze the causes and consequences of man-made and natural emergencies on the territory of Ukraine, we will use statistical data on the emergencies in Ukraine for 1997–2015 (Table 1) [14, 15].

From the data given in Table 1, we see that over a period of statistical observation in Ukraine there were more than 6 thousand emergency situations, of which 2.3 thousand – of a natural nature and 3.4 thousand – technogenic character, that is, on average, the number of man-made ES is stable in 1.5 ± 0.1 times exceeds the number of extraordinary natural events. Note that statistical data on the emergence of social character began to be published in the report since 2003, and their total number for the years of observation (2003–2015) is 218.

Over 18 years of emergency observations died more than 7.5 thousand people and injured more than 30 thousand people, and each victim of the EC has four injured persons. It is also evident that the number of emergencies in Ukraine, due to the efforts of the State Emergency Service, is gradually decreasing. Also, the number of deaths and injuries decreases because of these events. However, if the number of deaths is attributed to the corresponding number of ESs, then it becomes clear that the specific number of victims is on the contrary increasing. (Fig. 1).

So, if at each ES on average about one person perished in 1997, in 2016 this figure could already be about

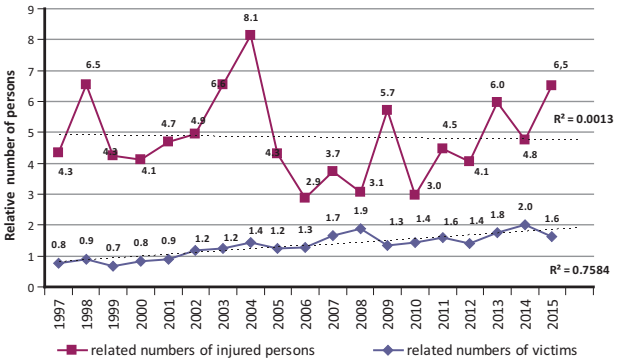

Fig. 1. The number of deaths and injuries in emergency situations in Ukraine during the period 1997–2015

two people (according to the trend in the form of a dotted line in the lower graph of Fig. 1, which simulates the number of deaths per year: $y = 0.0599x + 0.7261$, $R^2 = 0.76$), consequently, the severity of the consequences of the ES, expressed in the specific number of deaths per event, is indeed gradually increasing.

Concerning the specific number of victims, then, according to the upper graph in Fig. 1, the reliable dependence of its change in time failed to establish (the linear regression equation: $y = -0.0091x + 4.9316$ close to the horizontal line at a rather low reliability – $R^2 = 0.0013$). However, on average, 4.8 ± 0.63 people suffer from each emergency in Ukraine.

Table 1

Statistical data on emergencies in Ukraine 1997–2015 [14, 15]

Years	Emergency situations (ES)			All ES	Persons died as a result ES	Affected people as a result EC
	Natural character	Technogenic character	Social character			
1997	207	315	no data	574	436	2484
1998	239	273	no data	578	516	3774
1999	190	250	no data	503	336	2139
2000	139	261	no data	463	386	1909
2001	133	242	no data	436	391	2044
2002	121	208	no data	351	418	1733
2003	111	195	9	315	388	2064
2004	100	156	30	286	412	2330
2005	129	212	27	368	456	1580
2006	137	207	20	365	463	1046
2007	152	196	20	368	614	1377
2008	126	165	21	312	587	959
2009	117	130	17	264	356	1511
2010	108	130	16	254	361	753
2011	77	134	10	221	355	985
2012	74	120	18	212	301	861
2013	56	75	12	143	253	854
2014	59	74	10	143	287	680
2015	77	63	8	148	242	962
Total	**2352**	**3406**	**218**	**6304**	**7558**	**30045**

In addition to human casualties, every emergency leads to significant material damage through the destruction (damage) of buildings and structures, roads, vehicles, etc. Data on the material damage caused to the economy of Ukraine because of the ES for the period from 1997 to 2014 are given in Table 2 (information and analytical report on emergency situations in Ukraine that occurred during 2015 [15] does not contain data on natural and man-caused damage to the ES).

As we see from the Table 2 data, the state's economy because of the EC suffered losses of more than 55.5 UAH billion, of which the losses caused by the natural EC, amounting to about 54.3 UAH billion, while losses from the man-made ES – about 1.3 UAH billion.

Based on the analysis, we conclude that the number of ESs of anthropogenic character in our country is 1.5 times greater than the number of events of a natural character, but the natural ESs causing the state much more material damage. Thus, on average, each ES of industrial character causes a loss of 0.45 ± 0.17 million UAH, while each natural emergency on the average leads to losses at the level of 42.97 ± 23.97 UAH million that is, on average 53 times more. The significant dispersion of losses from the natural ESs is due to a sharp increase in the magnitude of losses in 2000 (1.5 UAH billion – strong ice in the central and southwestern regions of Ukraine) and in 2008 (over 4.6 UAH billion – and catastrophic flood in the western regions of Ukraine).

It should also be noted that the incremental growth of specific losses from the man-made ES (see bottom chart in Fig. 2, approximated as the equation $y = 0.0402x - 80.256$; $R^2 = 0.3759$). This may be explained, on the one hand, by the gradual physical wear and tear of a significant part of the technological equipment, and on the other hand by inflation.

Table 2

Statistical data on emergencies in Ukraine for 1997–2014 [14, 15]

Years	Losses, UAH million	
	Natural ES	Natural ES
1997	150	45
1998	920	25
1999	300	25
2000	1 500	120
2001	635	20
2002	280	95
2003	470	45
2004	300	25
2005	239	70
2006	330	100
2007	673	153
2008	46 627	92
2009	310	190
2010	870	64
2011	67	27
2012	173	64
2013	291	61
2014	140	59
Total	**54274.5**	**1278.65**

Concerning the natural damage caused by natural disasters, they are also gradually increasing (the upper graph in Fig. 2), however, due to the significant spread of this value, there was no reliable dependence on the value ($y = 1.8728x + 6.18$; $R^2 = 0.0134$).

The next stage of the study was the search for patterns of mutual connection or the relationship between the frequency of emergencies of natural and man-made in the territory of Ukraine. In Fig. 3 statistics on the annual number of such ESs for the last 19 years (from 1997 to 2015).

As can be seen from Fig. 3, there is a strong linear relationship between the number of natural and man-made ESs in the form of the equation $y = 1.3x + 18.34$, which has a rather high reliability – $R^2 = 0.78$), that is, an increase in the number of emergencies of a natural character leads to the corresponding an increase in the number of industrial emergencies. 1.3 incidents of technogenic origin occur on each natural occurrence event, which may be explained by the fact that extraordinary situations of anthropogenic nature often arise because of natural disasters. Even in the absence of the natural ES,

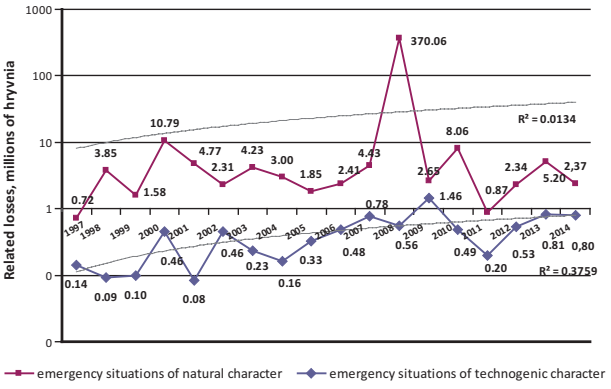

Fig. 2. Specific material damage from the ES of man-made and natural character in Ukraine for the period of 1997-2014

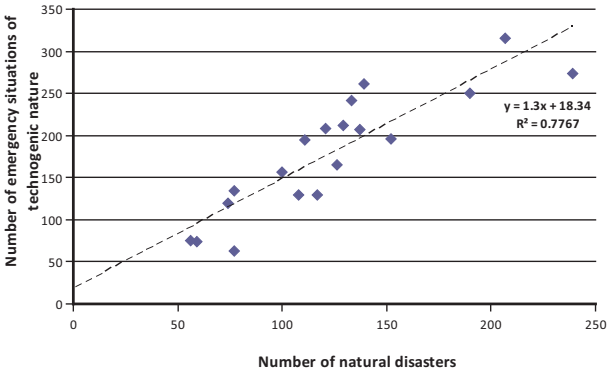

Fig. 3. Dependence between the frequency of emergencies of natural and man-made nature in Ukraine

the number of events of anthropogenic nature is 18.3, which may be due to a significant number of potentially dangerous objects on the territory of the country, as well as their unsatisfactory technical condition.

The next task of the study was to find out exactly what natural emergencies make the most contribution to the formation of the state of anthropogenic emergency.

According to the National Classifier of Emergencies DK 019: 2010, the class of natural emergencies (code 20000) in Ukraine includes the following subclasses: geophysical emergency (code 20100); geological emergency (code 20200); meteorological emergency (code 20300); hydrological emergency (marine – code 20400 and surface water – code 20500); ES related to fires in natural ecological systems (code 20600); medical and biological emergency (code 20700).

In turn, the subclass of medical-biological emergency is subdivided into the following groups: ES, associated with infectious diseases of people (code 20710); ES related to poisoning of people (code 20720); ES related to infectious diseases of farm animals (code 20730); ES related to massive poisoning of farm animals (code 20740); ES related to the mass death of wild animals (code 20750); ES related to damage to agricultural plants by diseases and pests (code 20760).

In Table 3 provides statistical data on the emergence of the main subclasses and groups of natural disasters in Ukraine for the period from 1997 to 2015. Data are presented both in pieces and in percentage to the total annual number of natural disasters.

As we see from Table 3, there is a positive dynamic in almost all the above-mentioned subclasses and groups of the ES, that is, the number of natural disasters gradually decreases. Even more clearly this dynamic illustrates the Fig. 4: during the last 19 years of observation, the number of meteorological, hydrological, geological, medical, biological ES has significantly decreased. As for the emergency, associated with fires in natural ecological systems, their number varies significantly from year to year, but does not significantly decrease.

In Fig. 5 representations of the distribution of the ES of natural character by subclasses and groups, based on the data of the Table 2. Most of the ES from year to year falls on the medical-biological emergency – an average of 58.1 %, of which ES, associated with infectious diseases of people, averaging 22.4 % of cases. ESs associ-

Table 3

Statistical data on the main subclasses and ethnic groups of the ES in Ukraine that arose between 1997 and 2015 [14, 15]

Years	Geological ES (code 20200)		Meteorological ES (code 20300)		Hydrological ES (code 20400 and 20500)		Fire in natural ecosystems (code 20600)		Medico-biological ES (code 20700)					
									infectious diseases of people		poisoning people		infectious diseases of farm animals	
	pcs.	%	pcs.	%	pcs.	%	pcs.	%	pcs.	%	pcs.	%	pcs.	%
1997	12	6	69	33	18	9	5	2	30	14	52	25	18	9
1998	15	6	49	21	35	15	28	12	39	16	58	24	13	5
1999	10	5	47	25	13	7	27	14	31	16	50	26	10	5
2000	5	4	34	24	4	3	15	11	35	25	27	19	17	12
2001	6	5	44	33	8	6	17	13	19	14	25	19	13	10
2002	3	2	33	28	7	6	19	16	19	16	29	24	10	8
2003	2	2	24	22	8	7	4	4	25	23	42	38	3	3
2004	1	1	22	22	7	7	3	3	14	14	47	47	5	5
2005	11	9	24	19	2	2	7	5	34	26	39	30	8	6
2006	15	11	21	15	14	10	9	7	25	18	34	25	17	12
2007	15	10	37	24	4	3	30	20	19	13	34	22	13	9
2008	8	6	22	17	1	1	28	22	14	11	48	38	5	4
2009	7	6	28	24	4	3	20	17	19	16	38	32	1	1
2010	12	11	34	31	4	4	5	5	14	13	37	34	2	2
2011	3	4	11	14	3	4	4	5	24	31	26	34	5	6
2012	1	1	20	27	2	3	15	20	10	14	21	28	5	7
2013	2	4	12	21	2	4	2	4	38/68*					
2014	0	0	9	15	2	3	6	10	25	42	12	20	5	8
2015	2	3	2	3	1	1	13	17	27	35	13	17	19	25
Average	6.8	5.0	28.5	22.1	7.3	5.1	13.5	10.8	24.3	22.4	35.1	28.0	9.4	7.6

*Note: *The National Report for 2013 specifies only the total number of medical and biological emergencies, without division into groups*

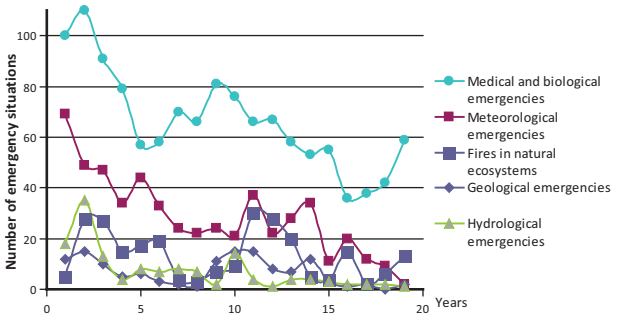

Fig. 4. The dynamics of the emergence of natural disaster in Ukraine for 1997–2015

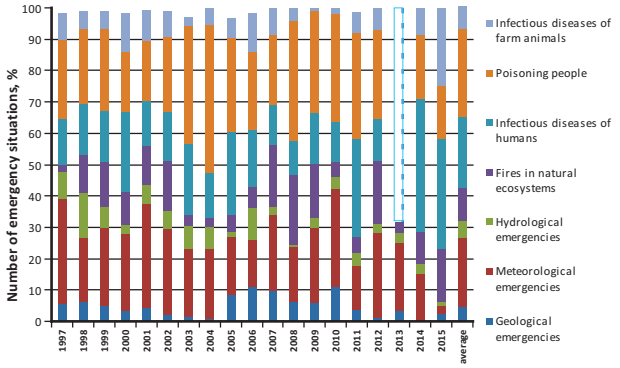

Fig. 5. Distribution of subclasses and groups of natural disasters

ated with poisoning people – 28.0 % and ES, related to infectious diseases of farm animals make up 7.6 %. However, as we believe, despite such many ESs of medical and biological character, in most cases they do not cause a man-made emergency.

According to the National Classifier of the DK 019: 2010, the following subclasses are classified in the category of man-made emergencies (code 10000): ES due to accidents or catastrophes in transport (code 10100); ES as a result of fires, explosions (code 10200); ES as a result of accidents with the release of hazardous chemicals, minerals on other objects (code 10300); ES because of the presence in the environment of harmful and radioactive substances exceeding the MPC (code 10400); ES due to accidents with ejection (threat of ejection) of radioactive (code 10500); ES due to the sudden destruction of buildings and structures (code 10600); ES due to accidents in power systems (code 10700); ES due to accidents in life support systems (code 10800); ES due to the failure of telecommunication systems (code 10900); ES as a result of accidents at the treatment facilities (code 11000); ES due to hydrodynamic accidents (code 11100); ES due to accidents in oil and gas industrial complex systems (code 11200).

Of all the subclasses of the ES of the natural character, it is geophysical, geological, meteorological and hydrological ESs can cause the aforementioned man-made accidents and catastrophes. Of these, according to the statistical analysis, the first place is meteorological emergency situations – an average of 22.1 % of cases annually. It may be ES associated with a heavy rain, a large hail, a strong snowfall or strong heat, strong wind, dust storm, snow sticking, heavy icing, snow thunder, blizzard, strong fog, etc.

The second place at the frequency of occurrence is the subclass of the EC, associated with fires in natural ecological systems, – on average annually 10.8 % of cases. These emergency situations may be caused by the man-made ESs, but considering the territorial specifics of these events (forest fires, steppe fires, agricultural fires or peat bogs), their ability to provoke man-made accidents and disasters is limited.

In the third place, the frequency of occurrence with almost the same result are geological and hydrological ESs – respectively 5.0 and 5.1 % cases annually. Geological emergency situations include: eruption of mud volcanoes, landslides, landslips or landslides, settling (plowing) of the earth's surface, karst failures and rising groundwater level (flooding). According to the hydrological marine emergencies and the surface waters ES include: high sea excitement and reservoir, high or low sea level, early ice, threatening icing of vessels, high water level (waterfalls, floods), shallow waters, traffic jams, snow avalanches, low water levels, intense ice floes and flooding. All these emergency situations, undoubtedly, can also be the cause of man-made accidents and catastrophes.

Undoubtedly, the most destructive potential of all emergency situations of a natural character is the geophysical emergency, namely the ES, associated with the earthquake (code 20110). They can provoke almost any man-made disaster, but fortunately, during the period of statistical observations, such events in our country were not recorded.

Conclusions and prospects for the development of the direction. Summing up the results of the performed studies, we can draw the following conclusions:

1. On average, the number of man-made emergency situations in Ukraine is 1.5 times higher than the number of natural disasters, but the extreme natural disasters cause the country significant material damage. Thus, on average, every ES of an industrial character causes losses by 0.45 ± 0.17 UAH million, while each emergency on the average results in losses at the level of 42.97 ± 23.97 UAH million.

2. The severity of the consequences of emergencies, expressed in terms of the specific number of people died per incident, is gradually increasing, and now it is about two people per ES, and an average of five people harmed in every emergency in Ukraine.

3. There is a strong linear regression relationship between the amount of natural and man-made ES, which is described by the equation $y = 1.3x + 18.34$ ($R^2 = 0.7763$), that is, for each negative event of natural origin with a high reliability, 1.3 negative events of technogenic origin.

4. Among emergency situations of a natural character that can cause the industrial emergency, the first place is meteorological emergencies – an average of 22.1 % of cases annually.

Finally, we should note that without a detailed analysis of the current state of technogenic and natural safety and monitoring it in the long-term dynamics, it is impossible to provide a reliable forecast of the conse-

quences of ES and to develop appropriate measures to reduce the risks of their occurrence; therefore, further accumulation and analysis of statistical data on the emergence of ES is prerequisite for elaboration of long-term, medium-term and short-term forecasts for taking appropriate decisions on prevention and liquidation of emergencies.

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Мета. Визначення тенденцій і закономірностей виникнення надзвичайних ситуацій в Україні для їх подальшого прогнозування й попередження.

Методика. Базувалася на системному аналізі надзвичайних ситуацій природного й техногенного характеру з оцінюванням і прогнозуванням частоти їх виникнення на основі використання статистичного аналізу динамічних рядів і побудови їх трендів.

Результати. Встановлено, що кількість техногенних надзвичайних ситуацій в Україні в середньому у 1,5 рази перевищує кількість природних. З усіх підкласів надзвичайних ситуацій природного характеру перше місце посідають метеорологічні надзвичайні ситуації – щорічно в середньому 22,1 % випадків, друге – пов'язані з пожежами у природних екологічних системах (10,8 % випадків), а третє – геологічні й гідрологічні (5,0 та 5,1 % відповідно). Визначено, що кожна надзвичайна ситуація техногенного характеру спричиняє державі збитків на $0{,}45 \pm 0{,}17$ млн грн., а кожна надзвичайна ситуація природного характеру у середньому призводить до втрат на рівні $42{,}97 \pm 23{,}97$ млн грн. Доведено, що 97,83 % матеріальних збитків, завданих економіці держави, спричинені надзвичайними ситуаціями природного характеру, а решта – техногенного, питомі збитки від яких мають тенденцію зростання.

Наукова новизна. Уперше на основі аналітичних досліджень встановлено, що між кількістю надзвичайних ситуацій природного й техногенного характеру існує тісний зростаючий лінійний зв'язок, який описується рівнянням $y = 1{,}3x + 18{,}34$ ($R^2 = 0{,}7763$). На кожну негативну подію природного походження з досить високою достовірністю припадає 1,3 негативні події техногенного походження.

Практична значимість. Результати дослідження можуть бути використані для розробки прогнозів і прийняття відповідних рішень щодо попередження й ліквідації надзвичайних ситуацій.

Ключові слова: *надзвичайна ситуація, аварія, техногенний ризик, екологічна безпека*

Цель. Определение тенденций и закономерностей возникновения чрезвычайных ситуаций в Украине для их дальнейшего прогнозирования и предупреждения.

Методика. Базировалась на системном анализе чрезвычайных ситуаций природного и техногенного характера с оценкой и прогнозированием частоты их возникновения на основе использования статистического анализа динамических рядов и построения их трендов.

Результаты. Установлено, что количество техногенных чрезвычайных ситуаций в Украине в среднем в 1,5 раза превышает количество природных. Из всех подклассов чрезвычайных ситуаций природного характера первое место занимают метеорологические чрезвычайные ситуации – ежегодно в среднем 22,1 % случаев, второе – связанные с пожарами в природных экологических системах (10,8 % случаев), а третье – геологические и гидрологические (5,0 и 5,1 % соответственно). Установлено, что каждая чрезвычайная ситуация техногенного характера наносит государству ущерб на 0,45 ± 0,17 млн грн., а каждая чрезвычайная ситуация природного характера в среднем приводит к потерям на уровне 42,97 ± 23,97 млн грн. Доказано, что 97,83 % материального ущерба, причиненного экономике государства, вызвано чрезвычайными ситуациями природного характера, а остальные – техногенного, удельные убытки от которых имеют тенденцию роста.

Научная новизна. Впервые на основе аналитических исследований установлено, что между количеством чрезвычайных ситуаций природного и техногенного характера существует тесная возрастающая линейная связь, которая описывается уравнением $y = 1{,}3x + 18{,}34$ ($R^2 = 0{,}7763$). На каждое негативное событие природного происхождения с достаточно высокой достоверностью приходится 1,3 негативные события техногенного происхождения.

Практическая значимость. Результаты исследования могут быть использованы для разработки прогнозов и принятия соответствующих решений по предупреждению и ликвидации чрезвычайных ситуаций.

Ключевые слова: *чрезвычайная ситуация, авария, техногенный риск, экологическая безопасность*

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