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EVALUATION OF EMERGENCY EXOGENIC PROCESSESS IN ECO-GEOSPHERE OF CENTRAL BLACK-EARTH REGION

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In accordance with United Nations International Strategy for Disaster Reduction (UNISDR) hazardous environmental eco-geosphere conditions of water collection sites on minor and medium rivers were analyzed. As the result of this analysis main negative exogenous processes, their features and intensity of water-erosion, karst, landslide, suffusion and subsidence processes, which are significant factors in the occurrence of emergency situations, were examined. Study of emergency situations in Central Black Earth Region allowed to classify them by types, classes and scale and furthermore to highlight zones of the most intensive exogenous hazards.
Keywords: Exogenous processes, emergency situations, Central Black Earth Region, hazardous eco-geosphere factors, territory zoning.

INTRODUCTION

Modern world can be characterized by a numbers of natural and industrial disasters due to increased anthropogenic pressure on the environment. Said disasters are already become a global problem that cannot be solved by individual country and requires attention from global community [10].

Hyogo Framework for action that was adopted by 168 countries from 2005 until 2015 created opportunity for United Nations Office for Disaster Risk Reduction (UNISDR) to realize its plans for reducing hazardous emissions and their influence on the environment. It should be an international program where different departments and countries can solve a common problem of environmental degradation.

Main idea of UNISDR includes:

- Increase social integrity in order to minimize economy, natural and human loses when endangered by ecological disasters;
- Creating plans and countermeasures, in case of anthropogenic and natural disasters, with special attention to people's needs, agrarian sectors and cities.
- Encouraging cooperation among nations and governments on regional and global levels especially for creating environmental friendly initiatives.

Said initiatives helped authors to study Central Black-Earth Region (CBER) which has some environmental problems. This region has combination of tense ecological situations (82%) in agricultural zones and hazardous ecological situations (18%) in industrial zones [5].

Goal of this research is to analyze dangerous natural and anthropogenic factors as a source of disasters in CBER.

Main research objectives:

- Identify hazardous factors of CBER and rate them according to scale and intensity.

- Establishing commonality between types and characteristics of natural disasters and specifics of territory where they occur for creating a suitable prevention and response plan.
- Zoning and rating territory depending on intensity of hazardous anthropogenic processes.

MATERIALS AND METHODS

CBER is located on South side of Central Russia and has intercontinental geographic location. This region consists of: Belgorod region, Voronezh region, Kursk region, Lipetsk region, Orel region, Tambov region. Size of CBER is 192,4 thousand km^2.

Region has agrarian-industrial economic specialization which includes machine manufacturing, mining, metallurgy, chemical and food industry. Agrarian sector is specialized on grain, industrial crops and animal farming.

CBER has continental climate, terrain consists of Central Russian Upland and Kalach Upland located on West and South-East Oksko-Donsk lowlands on East. Uplands are often and deeply dissected, watersheds are located around 200-250 meters, lowlands are not higher than 150-180 meters with flat terrain rarely dissected cloughs [5].

Region has developed ravine plantations with 0,5 – 2,0 km^2 density [8].

Terrain has important role in spreading of atmospheric precipitation and creating vegetative ground cover. Genetic affinity between soil, terrain and climate are shown in edaphic-climatic zone of CBER (fig. 1) [2].

In CBER there is high anthropogenic load on environment which leads to high ecological tension [6].

Research methods: comparative geographic, statistical, cartographic, field research, analytical, cluster analysis method.

Research includes analysis of natural and climate factors, that increase possibility of emergency situations in CBER [1]. Zoning of the region with emphasis on probability of emergency situations was carried out using the basin approach, which allows us to consider river basins as natural cells of the geographic shell in which water and land resources are formed, and as natural-economic systems, the boundaries of the catchments of small and middle rivers [3].

We took into account: the nature of the terrain-forming rocks, geomorphological conditions, water regime of territory, the use of land in human economic activity.

Rating of cloughs in CBER was conducted with factors of consistency (km/km^2) and density (u/km^2).

Catchment grouping of small and medium-sized rivers in the region according to emergency situations was carried out by us using the cluster analysis method [4].

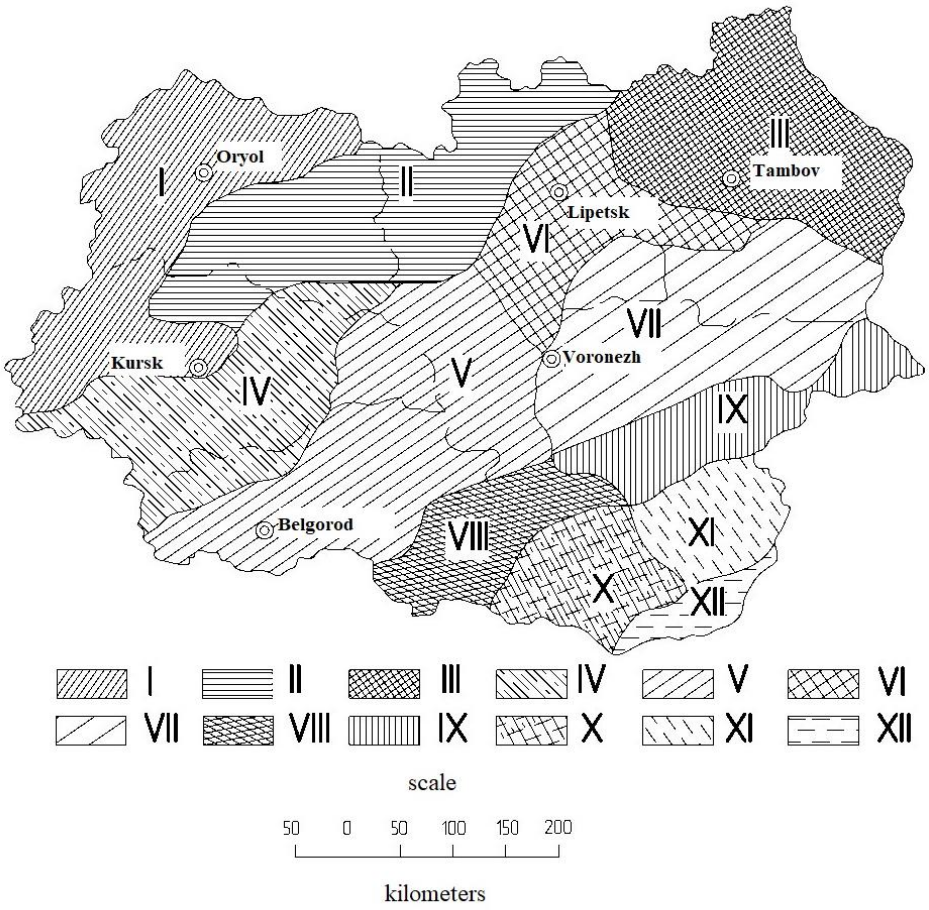


Fig. 1. Edaphic-climatic zone of CBER

I – grey forest and bleached black-soil; II – leached black soil; III – leached black soil; IV – weakly leached common and leached; V - common medium and leached clack soil; VI –common medium and leached; VII – common powerful and medium; VII – common; IX – common; X – common; XI – common; XII – common low and south black soil.

PRESENTATION OF THE MAIN MATERIAL

Analysis of natural disasters in CBER allows us to name them as “non-deliberate” natural and mark-out sub-classes such as: lithospheric, atmospheric, hydrospheric, including groups and types of emergency. In terms of scale, natural hazards are divided into levels: local, municipal, intermunicipal, regional, interregional, federal (Table 1).

Table 1

Natural hazards in CBER

Types of	Class	Subclass	Group	Disaster types	Hazard level					
					Local	Municipal	Inter-municipal	Regional	Multi-regional	Federal
Unintended	Natural	1. Lithospheric	1 Endogenetic	1 Earthquakes	■					
			2 Exogenetic	1 Gully erosion	■		■	■		
				2 Landslides		■				
				3 Karst dips	■		■	■		
				4 Ground drawdown	■	■		■		
				5 Shoreline erosion				■		
				6 Silting		■	■	■		
		2. Atmosphere	3 Climate extremes	1 High temperatures	■					
				2 Low temperatures	■					
				3 Heavy rain	■		■			
				4 Thick squall		■		■		
				5 Snowfall	■					
				6 Ice and frost	■	■				
				7 Blizzards			■	■		
				8 Wind (Sandstorms)	■					
				9 Snow cover	■	■				
				10 Fog	■					
				11 Droughts	■					
				12 Frost injury	■					
		3. Hydrosphere	4 Hydrogeological	1 Floods during the spring			■	■	■	■
				2 Water shortage, river drying			■			
				3 Groundwater level change			■			

■ - Hazards

Exogenetic natural hazardous factors in CBER are ravine erosion, soil slip, karst dips, subsidence, shore processing, siltation.

Intensity of said factors depends on environment in the region and can be used for describing scale and type of emergency situation.

Analysis of CBER according to development process of emergency situations allowed us to divide this region into 10 zones (fig.2).

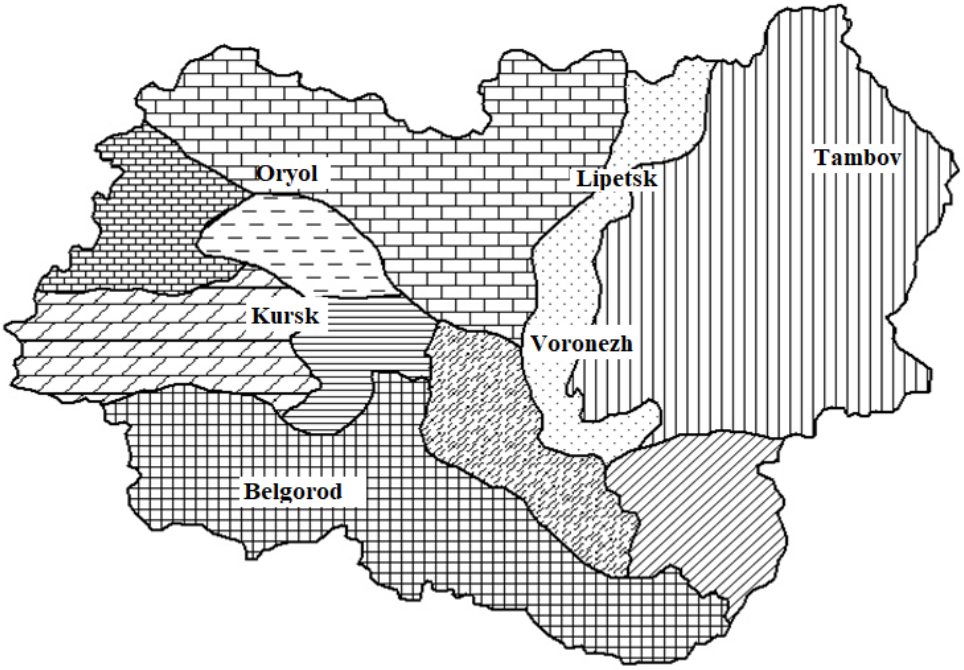
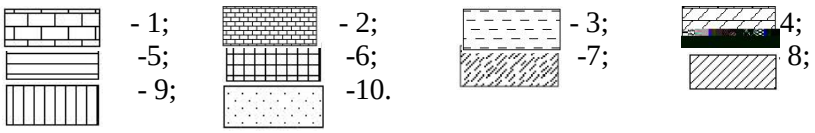


Fig. 2. Areas of the CBER with different conditions which depends on type of emergency situations



Zones: 1 - northern; 2 - northwest; 3 - the upper reaches of the Oka and Sosna rivers; 4 - western; 5 - central; 6 - southern; 7 - central (right bank of the Don); 8 - southeast; 9 - the area with sand terraces of the Don and Voronezh; 10 - northeast

Natural factors that cause natural disasters in different zones of CBER are given in table 2.

Table 2

Factors of emergencies in the framework of territorial-geological zoning of the CBER

Zone	Geomorphic rocks	F_1	F_2	F_3	F_4	F_5	F_6
I	Upper Devonian Limestones	9.5	1.3	132	1.2	8.8	61
II	Sands, clays of the Cretaceous	8.0	1.3	122	1.6	8	59
III	Sands, clays of the Cretaceous	8.2	1.2	120	0.9	9.0	62.2
IV	Mergel Upper Cretaceous	6.1	1.2	107	0.8	10.0	68.0
V	Mergel Upper Cretaceous	7	1.1	116	1	5.2	61
VI	Chalks and marls of the Upper Cretaceous	7.7	0.9	140	1	9.6	60
VII	Quaternary loam, Cretaceous, Upper Cretaceous	8	1	149	0.7	9.2	61
VIII	Quaternary loam, Cretaceous, Upper Cretaceous	7.7	1	147	0.5	10.1	55
IX	Quaternary Alluvial Sands	7.8	1	108	0.5	10	54.2
X	Glacial Quaternary Loam	2.4	0.8	92	0.5	14.1	57

F_1 - atmospheric precipitation infiltration,%; F_2 - coefficient of moisture; F_3 - depth of the basis of erosion, m; F_4 - density of the valley-beam section, km / km^2; F_5 - afforestation of the territory,%; F_6 - plowed land,%.

Depositional features of Geomorphic rocks allow us to identify shape of cloughs, density of compartmentalization, shapes of clough banks, scales of catchments.

The nature and intensity of hazardous exogenous processes on the catchments of the Central Black Sea rivers are shown in Table 3.

Table 3

Characterization of exogenous processes in the catchments of medium and small rivers of the Central Black Earth Region

Zones	Catchments of small and medium rivers	Exogenous processes
1	2	3
I	Vyteben, Nougr, Oka, Zon, Rybnitsa, Zusha, Neruk, Semenek, Lubovsha, Trudy, Bolshaya Chernava, Sosna, Olim, Bol, Vereyka, Vyazovka, Krasivaya Mecha, Snova, Veduga, Devitsa.	Gully erosion (1), Flat flush (2), karst (1) landslides (2), Ground subsidence (2)
II	Novlya, Nerussa, Swapa	Gully erosion (2), rainwash (2)

Continued table 3

1	2	3
III	Usoja, Tuskar	Gully erosion (3), rainwash (2), karst (3), soil subsidence (2)
IV	Seym, Amon'ka, Kleven'	Gully erosion (3), rainwash (2), karst (3), soil subsidence (2)
V	Tim, Kshen’	Gully erosion (3), rainwash (1), soil subsidence (3)
VI	Ilek, Sudzha, Pena, Psell, Vorksla, Khar'kov, Sev, Donets, Korocha, Nezhegol', Oskol, Valuy, Aydar, Belaya	Gully erosion (1), karst (2), rainwash (1), landslide (2) soil subsidence (3)
VII	Nizhnyaya Devitsa, Potudan', Tikhaya Sosna, Useredets, Ol'khovatka, Rossosh', Chernaya Kalitva, Boguchar, Levaya Bogucharka	Gully erosion (1), rainwash (1), karst (2), Landslide (1)
VIII	Chigla, Osered', Gavrilo, Tolucheyevka, Podgornaya, Manina, Kriusha, Mamonovka	Gully erosion (1), karst (3), rainwash (2), landslide (3) soil subsidence (1)
IX	Don, Repets, Ranova, Yagodnaya Ryasa, Ryasa, Ilovay	Gully erosion (3), karst (3), rainwash (3)
X	Lesnoy Voronezh, Pol'nyy Voronezh, Voronezh, Matyra, Plavitsa, Baygora, Usman', Khava, Khvorostan', Matyra, Bityug, Ertil', Kurlak, Chigla, Tsna, Koshma, Lesnoy Tambov, Sukhaya Lipovitsa, Ira, Kalais, Mokraya Panda, Vyazhlya, Vorona, Shibryayka, Tokay, Yelan', Savla, Karachan, Khoper	Gully erosion (3), rainwash (3), soil subsidence (2), subsurface erosion (1)

I, II, III, IV, V, VI, VII, VIII, IX, X - areas with different conditions for the development of exogenous processes. The numbers in parentheses indicate the degree of intensity of these processes: 1 - strong; 2 - medium; 3 - weak and very weak.

Among the dangerous natural processes of the CBER, the most widespread and significant is ravine erosions. Factors for the development of this process are:

- climate conditions which cause spring runoff with a short period of snowmelt, when

up to 70% of this runoff rolls off the surface of river catchments, creating conditions for the development of erosion;

- relief and steepness of the slopes.

The greatest ravine hazard with a density of ravines of more than 0.8 km / km2 and their density of more than 0.5 pcs / km2 is noted in Belgorod, Voronezh, Kursk, Lipetsk, Oryol regions. Tambov region isn't affected as much as other regions (Fig. 3).

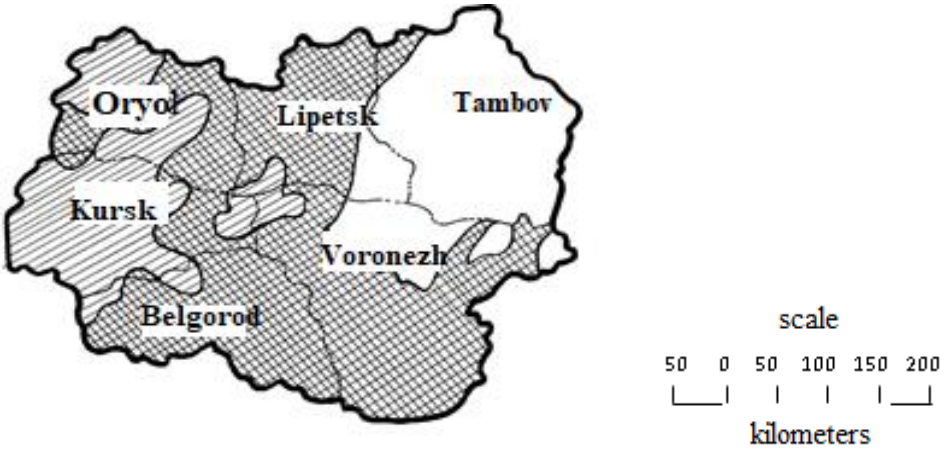


Fig. 3. Threat levels of ravine erosions

- low; - medium; - high.

In CBER, the relief-forming rocks are mainly represented by carbonates, and therefore karst processes are well developed in this territory (Fig. 4). In this case, the so-called covered karst is located here, the formation of which is associated with Upper Devonian limestones, as well as chalk and marls of the Upper Cretaceous age, covered with sand and clay of the Quaternary along with soil and vegetation cover.

Development of karst processes in the Oryol region and in the north-west of Lipetsk region has a potential hazard. In this regions the karst damage to the territory exceeds 25%, the rate of karst denudation is up to 5 m3 / m2, the surface diameter of karst forms reaches 30 m, in places up to 150 m, and the risk of sinkholes amounts to: one sinkhole per 1 km2 in 10 years. In this area natural hazards cause destruction of industrial and civil structures, damage to communications and few human casualties on a regular basis.

In the area of Upper Devonian limestones, about 1000 karst relief forms have been identified. Among them, the most common are karst funnels, which are often covered with forest and shrubs, as well as thickets of herbs and grasses.

Ravines and valleys of the Don, Vorgol, Bolshaya Chernava, Sosna, Vyazelka, Yemancha, Krasnaia Mecha and Palna rivers, where there are up to 20-30 karst landforms

per km^2, are especially prone to karst processes. On the west of the Lipetsk region, on the bottoms of ravines, karst funnels often form long chains of interconnected karst landscapes.

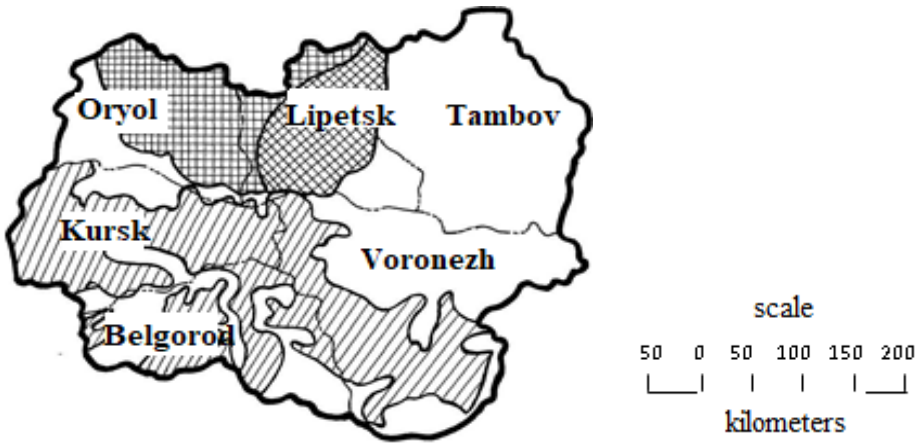


Fig. 4. The danger of karst processes.

- areas without karst rocks;
- Low level hazard
- Medium level hazard
- High level hazard

In the Oryol and Lipetsk regions, karst is a powerful landscape-forming factor and has a negative effect on hydroengineering facilities, as ponds and reservoirs fail due to filtration processes. On the right bank of the Don River, karst territory reaches 50%, in the center of the Lipetsk region - 30%, in the Voronezh river basin - 10%.

The possibility of emergencies related to karst development is now also noted in the west and south of the Voronezh region, in the Kursk and Belgorod regions, where the chalk-forming marls of the Upper Cretaceous age are the relief-forming rocks, and the territory is affected by 10-25%. Here, the rate of karst denudation is slightly lower, the diameter of the surface of karst forms is smaller, and the risk of failures is 0.5-1.0 per km2 over 10 years. However, in these areas there are cases of destruction of individual industrial and civil structures.

On the East European Platform, loess subsidence soils are distributed south of 560 N, therefore, the CBER is fully included in their distribution zone with the risk of emergency situations. Two degrees of danger of loess soil subsidence are noted here.

The first degree is dangerous, which is found in the north-west of the Oryol region,

the west of Kursk, the east and south of the Voronezh region. The second is a moderately hazardous degree of subsidence of soils, distributed throughout the rest of the region (Fig. 5, Table 4).

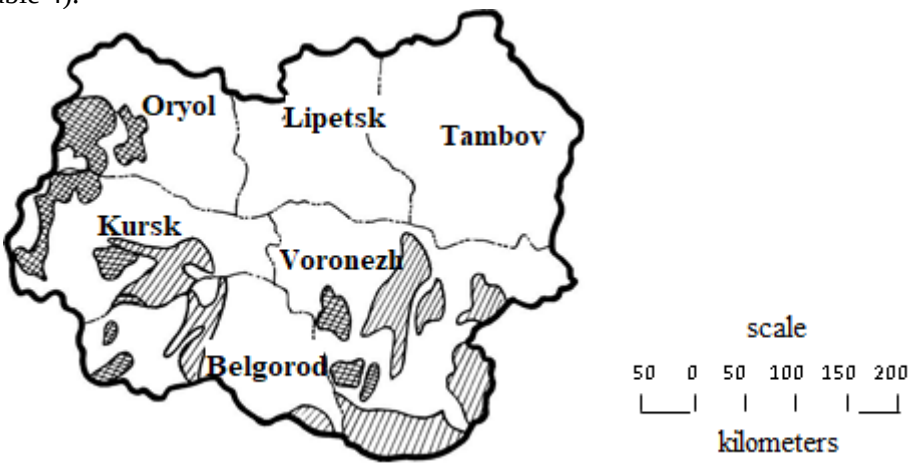


Fig. 5. Drawdown of loess soils

- Low hazard; - Medium hazard; - High hazard.

Table 4

The danger of subsidence of loess soils in the CBER

Degree of danger	Danger indicators of subsidence of loess soils					
	Affected area,%	drawdown at natural pressure, cm	drawdown at additional pressure, cm	area of simultaneous manifestation of subsidence, thousand m^2	maximum rate of subsidence development, cm / day	Consequences of subsidence
1	60-70	at 50	at 300	2,5	50-500	destruction of buildings and facilities with isolated cases of human harm
2	50-60	-	at 100	-	less then 0,5	rakes of buildings and structures, cracks in the walls, breaks in communications, failure of technological equipment, human casualties are possible

When assessing the conditions of emergencies in CBER, it is necessary to take into account the amount and conditions of channel reservoirs and ponds built in a ravine network. The volume of regulated surface runoff by ponds and reservoirs is 1990 million

m3. Most of the ponds are built in ravines, composed of poorly permeable rocks, and has a capacity of up to 500 thousand m3. Large channel reservoirs contain more than 100 million m3 of water. For example, the Voronezh reservoir has a capacity of 204 million m3 [9].

Also, a significant number of dams and waterworks at ponds and reservoirs are partially or completely destroyed, which creates a danger to the settlements located in the zone of their influence.

CBER is almost entirely part of a danger zone of processing and destruction of the reservoir shores. The length of destructible coasts in this region is from 30 to 70%, the specific volume of processing is from 12 to 70 thousand m3 / km / year, the average rate of degrading in individual reservoirs is more than 3 m / year. The destruction of land over 20 years of reservoir operation with an area of less than two km2 reaches 0.2 km2. The destruction of the reservoir coasts entails significant environmental and economic damage.

In CBER, there is a strong and complete siltation of the channels of small and medium rivers, as well as widespread erosion of river banks in the conditions of the free development of channel deformations (Fig. 6).

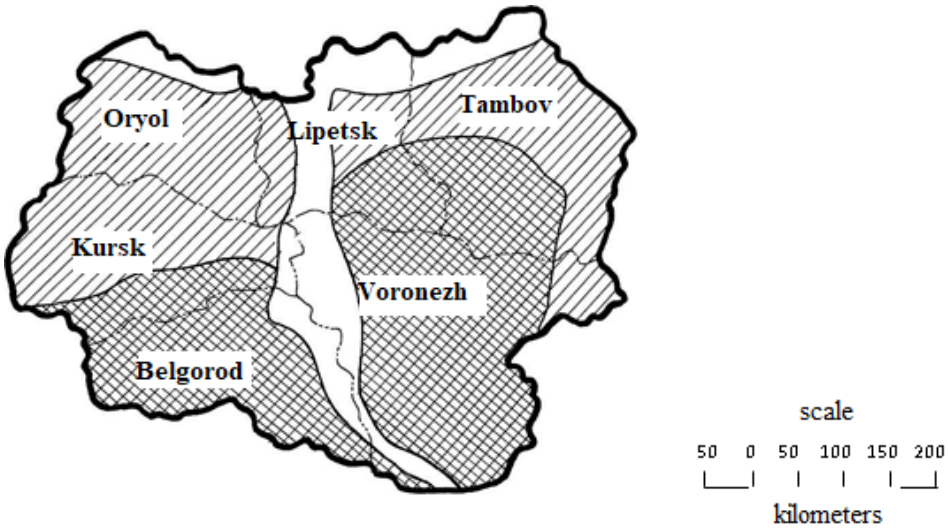


Fig. 6 - Siltation of channels of small rivers

- possibly medium siltation;
- high siltation;
- complete siltation.

The banks erosion of the Don river bed occurs at a speed of about 2 m per year, a mechanical change in the channel is observed at 25-50% of the river length.

Thus, on the territory of CBER, the Central Russian and Kalach Uplands are among

the most ravine-hazardous territories, with a high chance of emergency situations occurrence at the federal and regional level, and the Oka-Don Lowland has an insignificant degree of danger. The density of ravines in hazardous areas is now 2.1-5.0 pcs./km2; forecast: 5.1-10.0 pcs / km2, and the density of the ravine network: 0.5-1.3 km / km2; forecast: 1.5-3.0 km / km2. The average growth rate of the ravines is about two meters per year. Gullies create a significant dissection of agricultural land, which interferes with the operation of agricultural machinery and grazing, destroy communications and hydraulic structures; cause siltation of ponds and riverbeds; destruction of industrial, residential and construction facilities.

Also on the territory of the studied region karst processes are significantly developed, the highest intensity of which is noted in the Oryol and, in part, Lipetsk regions.

A dangerous degree of subsidence of loess rocks is found in the north-west of the Oryol region, the west of Kursk, the east and south of the Voronezh region.

The Central Black Earth Region is almost entirely in the zone of increased danger of processing and destruction of the banks of reservoirs.

In the characterized region, siltation of the channels of small and medium rivers is observed, which is assessed as strong and complete.

CONCLUSION

The studies conducted allowed us to identify the dangerous factors of CBER ecogeosphere affecting the occurrence of emergency situations: ravine erosion, landslide formation, karst, subsidence of loess soils, coast processing, channel processes;

The natural development of dangerous exogenous processes in combination with the accumulated and constantly growing anthropogenic load suggests an increased risk of natural and man-made emergencies.

As a result of the regionalization according to the conditions of emergencies, we have established areas of negative exogenous processes manifestation that causes emergency situations in CBER. The greatest number of dangers of a local level prevails in the Oryol and Tambov regions, municipal - in Voronezh, Lipetsk, Tambov and Belgorod, intermunicipal - in Kursk, Lipetsk and Voronezh.

The conducted studies serve as the basis for the development and implementation of risk management strategies and measures at all levels.

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ОЦЕНКА ЧРЕЗВЫЧАЙНЫХ СИТУАЦИЙ ЭКЗОГЕННЫХ ПРОЦЕССОВ ЭКОГЕОСФЕРЫ ЦЕНТРАЛЬНО-ЧЕРНОЗЕМНОГО РЕГИОНА

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В рамках Международной стратегии уменьшения опасностей бедствий (МСУОБ) проведен анализ опасных природных факторов экогеосферы Центрально-Черноземного региона на водосборах малых и средних рек. В результате проведенного районирования были установлены основные негативные экзогенные процессы, характер и интенсивность проявления водно-эрозионных, карстовых, оползневых, суффозионных и просадочных процессов, являющихся значимыми факторами возникновения чрезвычайных ситуаций. Изучение чрезвычайных ситуаций в исследуемом регионе позволило классифицировать их по типам, классам и масштабам, а также выделить области с наибольшим количеством природных экзогенных опасностей

Ключевые слова: Экзогенные процессы, чрезвычайные ситуации, Центрально-Черноземный регион, опасные факторы экогеосферы, районирование территории.

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