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VULNERABILITY ASSESSMENT AND PROTECTIVE MEASURES FOR NATURAL HAZARDS

T.B. Minakova, E.V. Buldakova*[1], A.V. Buldakov**, I.S. Savisko**
*Sergeev Institute of Environmental Geoscience Russian Academy of Sciences (IEG RAS), Moscow, Russia
**ZAO "REI-ECOAudit", Moscow, Russia

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Abstract: The most promising area of research for assessment of vulnerability of territories from natural processes should be based on structural-dynamic concept of geosystems. Its essence consists in transition, under external influences, natural systems from a state of stable in an unstable. At the same time is not excluded the possibility of evaluation of vulnerability of the territory with the status of components of the environment and objects under the influence of the natural processes.

Key words: vulnerability, geosystems, natural processes, geological assessment

Introduction

Any territory may be under the influence of various natural processes. Natural influences are natural phenomena, manifested as the powerful destructive forces usually are not subject to the management of a man, and slowly leaking, but permanent processes.

With all the surprises of a phenomenon it possible manifestation can be with varying degrees of probability predicted. However, as a result of their symptoms often arise natural disaster.

Natural phenomena - the causes of natural disaster

A one-time effects of natural disasters is repeated often, but is rapidly developing event. These include tropical cyclones, tornadoes, lightning, floods, tsunami, earthquakes, volcanic eruptions, landslides and other. Among sectional can distinguish subgroups of one-time (earthquake, and others) and reusable processes (floods, avalanches, surges, hurricanes, tornadoes, etc) (table. 1).

[1] Correspondence to: e_buldakova@mail.ru

Natural phenomena in many cases arise in interaction with each other, i.e. in paragenetic communication. Cyclicity manifestations in this case are usually broken: they occur much more frequently, their destructive power increases. Sudden impacts are not only characterized by unexpected events, short duration, but also the significant intensity and more grave consequences. Recurrence of one-off effects in one of the natural environments within the individual areas is characteristic practically for many processes floods.

Permanent impact event relatively continuously happens in time and space (karst, erosion and other). Among them are the subgroups of cumulative and extensive processes. These subgroups are significantly affected by human activities. When changes from permanent impacts accumulate, the area of their development is expanding, and the achievement of a critical level is accompanied by an «explosive» situation.

Table 1. Main natural processes

The spontaneous natural processes		Permanent natural processes	
Geological	Meteorological	Geological	Meteorological
		eutrophication	
earthquake	drought	flooding	
volcanic eruption	tornado	karst	swamping high water
mudslides	tsunami	erosion horizontal	
mudflow	flood*	erosion is ravine	
avalanches	hurricane	inclined washout	
landslides	flurry	subsidence of loess rocks	

* flood of natural-technogenic character

Some processes can occur in groups and synchronously, others consistently, in the form of a genetically caused chains, when some processes cause the other.

The natural processes varies considerably by:

– the reasons of occurrence of natural and man-made, as well as the accumulative situation emerging as a result of prolonged negative impact both reasons;
– time of the manifestation - permanent (flooding, erosion, karst), a long-seasonal (flood), short (a landslide, flooding accident at hydrofacility);
– square distribution – a large (erosion), local (karst);
– interaction processes - singly, in groups, the chains earthquake - mudflow - the destruction of forests - the development of erosive

processes, while reducing the volume of production of oxygen - deterioration of conditions of activity);
– intensity of impact - number of simultaneously discharging energy during the implementation process (the intensity of the geological hazards exogenous number is a function of volume and speed of a lump sum moving mass of rocks, water-stone and snow formations). Destructive impact intensity leads the integrity of the natural systems, destruction of biota and etc. in violation of their degradation;
– object impact - separate objects of the economy, the natural components, geosystem in general, the territory (as a set of geosystems);
– predictability - sudden (with the consequences of extraordinary situation) and expected (in advance предотвращаемые);
– consequences - material losses (loss of crops due to erosion, destruction of buildings due to the floods, karst); deterioration of the conditions of life (loss of comfort of living in the flood etc); damage to people's health and even human sacrifices (earthquake, avalanche, landslide); environmental damage (deterioration of the quality of individual components, their destruction, violation of stability of the entire geosystems).

The individual processes will change as their key characteristics and parameters.

The main natural factor determining the high rates of erosion, slope is the type of terrain and climatic conditions. Frequent summer droughts, sometimes accompanied by dry winds contribute blowing soil. Abundant rainfall contribute to the development of linear erosion. These processes are the cause of the loss of crops, expansion of the area of saline soils and biodiversity of the vegetation cover. Soils of light mechanical composition subjected to deflation. Intensive erosion processes are characteristic of the arable lands of the forest-steppe and steppe zones, and also in the foothills. Washed away soils depends on the steepness of slopes: washed away soil more than 60% is noted on a slope of more than 10 degrees. In Central black earth areas with a slope of more than 7 degrees washout of soil exceeds 11 t/ha grain Yield on slightly eroded lands reduced by 10-20%, and heavily eroded - 50-70%. Thus, material losses from planar erosion felt (Alekseev, 1988).

During the construction of reservoirs processing shores accompanied degradation, collapse and subsidence of the soil, especially in areas with large wave formation and with high coastal slopes, folded sandy loam and sandy soils.

Intensification of channel processes is also the reason for the significant erosion of the shores.

Karst-suffusion processes and sagging phenomenon are widely spread in the regions with loess rocks. They are manifested in relief in the form of shallow depressions - depressions and funnels several meters in diameter. Loess ground under its own weight hydrated strata deformed, that reduces the amount of breed, loss of carrying capacity and the formation of local terrain depressions. Karst is one of the most dangerous natural processes due to the suddenness of manifestations in the form of failures and subsidence of the land surface, sometimes reaching 100 and more meters in diameter and height.

Gravitational processes, common in the highlands include landslides, avalanches, mudflows, local activation, often near the engineering and economic objects.

Damage assessment in Russia

According to the calculations of the International Bank for reconstruction and development in Russia, the damage caused by hydro-meteorological phenomena ranges from 30 to 60 billion rubles per year. Hydro-meteorological phenomena were observed in our country almost every day. There is increase trend of their numbers in recent years. Therefore, grow and the economic losses from the effects of hydrometeorological disasters on agriculture and forestry of Russia. Associated with hydro-meteorological phenomena annual damage to the economy (still the USSR) only from 1963 to 1991 has increased more than in 4 times (Bedritsky at al., 2004).

In Russia, total area of lands exposed to flooding during floods is more than 88 thousand sq. km (about 5% of the country). The potential threat of flooding there are more than 40 major cities and several thousand other settlements (Malik, 2005).

The average annual flood damage in Russia is estimated at 41.6 billion rubles (in prices of 2001). In recent years there has been increased damage from floods in Russia (national report of the world conference on disaster reduction, 2005). Some authors indicate that in the first years of the XXI century high repeatability and disastrous floods has increased compared with the last decade of last century the average on 15%.

Thus, on a certain territory damage may occur as a result of either spontaneous manifestation of natural processes, or reaching the critical level results from the negative influence of natural processes over time.

The damage from the impacts of both natural and permanent processes (table.1) is many times greater than the damage from human impacts (except in emergencies). The structure of damage from the impact of natural processes on the recipients will be the following:

– damage to life and health (the social component of the damage);
– damage to economy - material losses (economic component is the cost of lost or damaged household objects, natural resources);
– damage to the natural environment (environmental component - the costs of restoration of the disturbed state of natural components and systems in general).

Protection from natural disaster

The task of engineering protection is to prevent, eliminate or reduce to an acceptable level of negative impact to protected areas, existing and related potential hazardous processes, prevention of emergencies, prevention of death of people, reduce the possible damages. Control measures vary greatly between, on the one hand, the type and intensity of the process, on the other - from the structure and condition of the recipient.

In addition to the form and nature of the acting natural process, design, measures of engineering protection based on the information about the boundaries of the protected territory, the peculiarities of its economic use and environmental values, the prescribed mode of management of nature reserves (reserves, agricultural land, etc), the sanitary norms. The basis for selecting protective measures should be the assessment of the territory on the rapids of a security, i.e. to determine its vulnerability to various natural processes.

For a choice of optimum variant of engineering protection measures should be substantiated and contain an assessment of the environmental, social and economic effects.

Ecological effect of engineering protection is estimated change in the natural resource potential of the protected area and its reproductive capacity. Social effects related to the improvement of living conditions of the population and preservation of the aesthetic value of the landscape.

The economic effect of engineering protection determine the size of prevented damage to the site or structure from exposure to hazardous processes less costs to the implementation of the protection. Damage includes loss from exposure to hazardous geological processes and the cost of compensation for the consequences of these impacts. Losses for individual objects are determined by the value of fixed assets on an annualized basis, and for the territories - on the basis of specific losses and the area endangered territory taking into account the long period of biological recovery and term of realization of engineering protection. All values are given to a single point in time, as the beginning of which is the date of the beginning of implementation of engineering protection. Under the avoided damages must be understood the difference between the damage refusal to conduct engineering protection and damage possible after the event.

Measures of engineering protection are complex, taking into account the forecast of change of state territory in connection with the construction of facilities engineering protection and development of a territory. The measures of engineering protection against different types of dangerous processes must be coordinated among themselves.

In the calculations of the attenuation (stabilization) of the dangerous geological process when you enter the engineering protection of dangerous geological process is considered as work complicated geotechnical system exposed to the threads of the “failure” and “restores”. For refusal to accept the accomplished fact of action (slumping, landslides, erosion, etc). According to this “failed” element of the system - the estimated amount of оползающего block soil, landslides etc. and “recovered” - in fact, the swelling of his part (SR XX.13330.2012).

For the operation of structures, reliability and efficiency of the engineering protection during construction and exploitation period of systematic monitoring.

Vulnerability of the territory

For prevention (reduction) of the expected damage from the impact of natural processes and selection of effective protective measures requires assessment of the vulnerability of the territory. It is based on the study of the interaction of natural processes, with the territorial object, accounting regularities of the processes and characteristics of the area in relation to various scenarios of the development of processes and expected consequences from them in the future.

Vulnerability assessment finds wide application in the field of forecasting natural processes and preventive measures that can be taken to mitigate the adverse consequences of impact of natural processes. Vulnerability assessment is often a qualitative, as qualitative assessments of the possible impacts of natural processes are depending on the type and nature of the impact, specific assumptions about future changes and analysis methods. Therefore, when such an assessment of the uncertainties remains regarding the nature, magnitude and rate of future change. Thus, relatively accurately assess the vulnerability of the territory is possible only for a specific process with the given scenario parameters. But this is not enough, because the reaction to such exposure to various natural components and objects of the economy will be different. The vulnerability of the territory will be different due to the different structure of natural systems and different base of geo-ecological condition of the territory.

Because of the vulnerability geosystems is a property the opposite of sustainability, i.e. indicates the inability to resist external influences based on the definition of the term «stability reserve», one could argue that the excess of the values of stability for a particular geosystems on one of the factors that determines the vulnerability.

In assessing the sustainability of the natural environment more productive is the approach based on geosystem concept of organization, because the parameters of the components in the natural complexes are of a certain dimension and the degree of homogeneity depending on the rank of geosystems (Kazakov, 1989). Thus, the vulnerability is estimated measure of the hazard potential threats on the basis of knowledge about dangerous events and sustainability of geosystems to their impact.

Most of the existing approaches to the assessment of vulnerability are not universal even within the same type of geosystem, because depending on the Genesis, nature and duration of use of the territory, the changes will have its own specifics. The choices of the parameters characterizing stability of the same natural ingredients to different types of effects, and when the same treatment is a rather complicated task (Grodzinsky, 1987).

The vulnerability assessment of natural complexes based on the integrated indicators of sustainability and degradation. On the basis of the obtained results was performed distribution of the integral index of PC vulnerability in 5 categories: a reduced - <0,20; moderate - 0,20-0,30; high - 0,31-0,40; high - 0,41-0,50; very high - >0.50 in (Shapligina, 2010).

Conclusion

It seems most promising direction of researches on assessment of vulnerability of territories from natural processes based on structural-dynamic concept of geosystems. Its essence consists in transition, under external influences, natural systems from a state of stable in an unstable. At the same time is not excluded the possibility of evaluation of vulnerability of the territory with the status of components of the environment and objects under the influence of the processes.

The consequences of the impact of natural processes, as mentioned above, it is appropriate to evaluate through the value of economic damage. Then the indicator of vulnerability can be seen as a reverse value of the expected damage from the effects of a natural process. The more damage the higher the vulnerability of the territory and the more important the implementation of protective measures. Kind of protective measures and the order of their realization is determined depending on the ratio of values of damage to individual processes and vulnerability of the territory to their impact.

Thus, the evaluation of vulnerability of the territory in the area of possible manifestations of the natural process is the basis for predicting the effects of negative impacts and the development of the system of protective measures.

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