PARTICULARITIES OF ECOLOGICAL RISKS IN WEST SIBERIA

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Abstract

Ecological risks here stand for the degree of possibility of cumulative manifestation of hazardous and disastrous effects of man impact on territorial natural complexes during a particular time span. Ecological risks in the territory of West Siberia have a certain set of particularities compared to those in other parts of the world. Potential ecological risks for the north of West Siberia are pollution of ecosystems with oil products, changes of geodynamic conditions of upper lithosphere horizons, permafrost degradation, and intensification of vertical movements of the earth's crust, which can bring about changes in the general base level of the territory, an activation of exogenous processes, etc. Southern areas of West Siberia, which are more urbanized and developed by man, have different natural conditions for carrying out economic activity. Ecological risks for this area are connected with agricultural activity and include mechanical soil devastation, pollution of groundwater with drainage of agricultural companies, etc.

Keywords: ecological risks, natural risks, natural complex, ecological damage, West Siberia.

1. Introduction

Changing interrelations in natural ecosystems, growing technogenic pressure on nature around the world have resulted over the last decades in ever growing number of critical ecological situations, emergencies and disasters, characterized by considerable financial and ecological consequences. Russia is not an exception: 26% of the country population live in the conditions of ecological trouble; about 45 thousand of dangerous industrial manufactures is located on the country's territory, including a large number of technogenic constructions, accidents on which can lead to disasters not only of regional and national, but also international scale (Management, 2000).

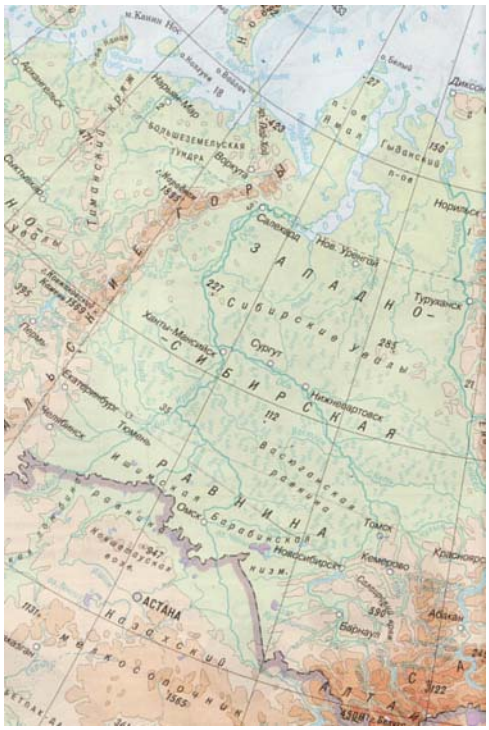

Figure 1. Geographical situation of West Siberia

Western Siberia is a physico-geographical formation located on the Western-Siberian Plain in the Russian Federation. From the west, it borders with the Urals Mountains. From the east, it is limited by the Yenisei range and the Central Siberian plateau, from the in the north is washed by waters of the Kara Sea (Fig. 1). The southern part of the plain is outside Russia, in Kazakhstan, and borders with Altai Mountains on the south-east. Western Siberia is one of the largest plains in the world, it stretches for almost 2500 km from north on south, with the area of around 3 million km^2. Here are located large enterprises of the energy production sector, ferrous metal industry, oil-and-gas production, petrochemical and nuclear industry. They, taken both separately and together, present real threat to environment and population living it it. On the Western Siberia territory, the following ecological risks can be distinguished, which lead to serious ecological consequences: leakages from dangerous waste burial facilities, pollution from industrial waters, oil and oil-product spills, accidents on atomic power stations, leakages from underground storages of oil-products, water pollution by solid wastes and rubbish, water pollution by agricultural waste waters, water pollution by waste clearing facilities, air pollution by industry and automobile transport, pollution of drinking water, etc. Only in the Khanty-Mansiysk autonomous region, the area of petropolluted lands makes up over 35 thousand hectares, over 500 of oil torches burn away over 6 bln cub.m. of oil gas, over 4000 of emergency oil leakages occurs in the oil pipeline systems annually. Further growth of anthropogenic pressure

on the region ecosystems can lead to a regional ecological catastrophe. In this connection, increasingly urgent becomes the prognoses for ecological risks consequences, in connection with the study of ecological conditions in Western Siberia.

2. Methodology of the assessment of ecological risks

We understand ecological risks as a probability of cumulative demonstration of dangerous and catastrophic consequences of anthropogenic influence on the socioecological systems of the territory, in the conditions of considerable uncertainties between the elements of environment and society. Ecological risks arise in the conditions of ecological danger, which brings destruction of human's habitat, flora and fauna, as a result of spontaneous economic development, natural catastrophes and anthropogenic accidents, resulting in the unstable functioning of ecological-economic systems. Ecological risks occur at the interaction of environment, social and ecological-economic systems. Increased impact of one of the elements results in sometimes unpredictable consequences in other. So, negative situation in the environment results in natural disasters and negatively affects social and economic aspects of man's life and activity; strong economic activity of Man results in the increased possibility of technogenic catastrophes and the growth of ecological risks; deterioration of environment in turn leads to adverse changes in the population health and the loss of the nations' genofund.

Ecological risk can be defined as multiplication of probability of the considered event or process by the magnitude of expected consequences or damage (Vaganov, 1999). Consequences always bring damage which can be expressed by quantitative or quality parameters, and the greater is the expected damage, the more significant is the risk. That's why, ecological risk *ER* can be defined as a multiplication of probability of a dangerous event or process connected with anthropogenic activity of man *(P),* by the magnitude of expected damage *(Q)*, where the damage is equal to the consequences of harmful anthropogenic or natural impact expressed in monetary form:

$$ER = P \cdot Q \qquad (1)$$

Thus, if some ecological danger is characterized by 10^{-1} degree of probability, and the total expected damage from this danger makes up 10 million rubles, the corresponding risk will be expressed as 1 million rubles. It should be mentioned that this approach is based on monetary expression of damage. At this, the probability of danger is calculated based on a time scale of previous events, and the greater is the time range connected with the studied phenomenon, the less is the error in calculations.

Table 1
Risk criteria for dangerous natural and anthropogenic situations
in the territory of Western Siberia

Name of risk factor	***Some threshold of probability of ecological danger***		***Average for West Siberia***
	in critical situation	***critical preceding period***	
Frost-free period, days	70 - 90	70 - 30	70-90
Soil freezing, m	3,5-5	1-3,5	1-2
Ravine growth rate, m/yr	> 5	2-5	2-5
Eddy wind, m/sec	> 25	20-25	15-20
The harmful substances in the atmosphere, t/km^2	> 10	5-10	0,12
The limiting threshhold of polluted waste waters, %	> 90	75-90	30,6
The danger degree of technogenic accidents and catastrophes	> 15	10-15	26

Another approach to the assessment of ecological risks is based on some critical threshold of probability of ecological danger, as an environmental problem occurs when its risk probability exceeds a certain limit, that is, becomes unacceptable. In order to determine the amount of risk, some quantitative indicators of risk are introduced, describing the amount of critical situations. Here the following criteria can be considered: the danger degree of technogenic accidents and catastrophes; the limiting threshhold of polluted waste waters and harmful substances in the atmosphere, the intensity of some natural processes. Assessment of risk

acceptability is a complex and ambiguous problem, as the question on acceptable level of ecological risk is solved differently in different countries. Table 1 shows the values of risk factors, calculated for the territory of Western Siberia. It can be seen from the table that risk values on harmful emissions into air and water basins are low – the harmful substances are dispersed over the large territory. But the risk of technogenic catastrophes is high, as many large industrial productions are located here, accidents on which can lead to unpredictable ecological consequences.

Based on the analysis of cartographical and statistical materials, available for the territory of Western Siberia, geomorphological and hydro-geological data for the last decades, we have studied and classified by the degree of danger the major ecological risks, which depend on environmental, geomorphological and geological conditions of Western Siberia.

3. Ecological risks on the Western Siberia territory

Ecological risks on the territory of Western Siberia have some particular features. The most important of them is based on the fact that Western Siberia, with its large area, is characterized by a great variety of environmental systems and geoecological conditions. These factors allow us to determine geographical differentiation of ecological risks, in the direction from north to south. The territory of Western Siberia can be divided into three major regions, by the degree of probability of ecologically dangerous situations: northern, central and southern.

In the northern area, oil-and-gas industry facilities are most significant and sometimes the only sources of man's influence on the environment. Ecological risks on this territory are high enough, as anthropogenic impact is directed to practically all elements of environment, including: air, surface and underground waters, vegetative and soil cover, long-term frozen rocks, etc.

The analysis of ecological consequences of economic activity has allowed us to reveal ecological risks potentially possible for this region: pollution of ecosystems by oil-products; changing of hydrological and hydro-geological regime of the territory; changing of geodynamic condition of upper layers of lithosphere; degradation of permafrost; activization of modern vertical movements of the Earth's crust that will lead to changing of the general erosion base of the territory and activization of exogenic processes (Semyonov, 1994).

Major factors of negative impact on the environment, when conducting exploration, preparation and production works on the oil and gas fields and pipelines, are the following: pollutant emissions into atmosphere; influence of sewage waters on land forms and natural water formations; pollution of ecosystems by oil-products, drilling reagents and other technological liquids; mechanical disturbances of soils and soil covers; thermal pollution of thick frozen rocks; changing of established conditions of heat-and-moisture exchange on the surface of permanently frozen beds; changing of hydrological and hydro-geological conditions of the territory; changing of thermobaric conditions and geodynamic condition of upper layers of lithosphere; impact on flora and fauna. For example, gas torch installations influence soil and vegetation cover in the radius of 200-250 m, completely destroying vegetation (Fig. 2) – the trees growing at a distance of up to 3 km from the torch installation are gradually drying and eventually perish (Kesselyman, 1981). Negative consequences are amplified by the conditions of permafrost, where the slightest impact on the environment sometimes causes enormous damage, as the processes of landscape transformations in the conditions of permafrost develop much faster than in other territories.

Figure 2. The influence of flare on growth in the south of Western Siberia (Kosov, 2004)

Over the last decades in ever is growing man-caused load on geological constituent of the environment. Separately should be noted risk factors of technogenic character, connected with geodynamical processes, as well as their geoenvironmental implications (Lygotin, 2007). So, non-uniform sagging of ground surface when extracting gas, changing of load-deformation condition of rocks, changing of temperature conditions and redistribution of pressure areas when laying communications and underground pipelines results in more active modern vertical movements of the Earth's crust, activization of cryogenic processes, increase of degassing (Griva, 2005).

The central area of Western Siberia is located in the taiga zone, which is a region of raised humidity, with large areas covered by forest alternating with swamps. Ecological risks here are not as high as in the northern area and mainly are connected with agricultural and industrial activities. For example, in the process of mechanical destruction of soil cover, partial or full destruction of humus horizon occurs, as soils in this region are characterized by weak stability against mechanical changes – even after one passage of a heavy caterpillar vehicle the humus layer with thickness of less than 10 sm it completely destructed (Solntseva, 1983). During construction works the materials from different soil horizons are mixed, vegetation is cut, and in marshy territories – already poor fertile vegetation layer is completely destroyed.

As a result of economic activities, mechanical changing of the landscape occurs. Technogenic landforms are gradually transformed and can be accompanied by secondary changes, of already greater scale. Numerous ravines and landslides are formed, which are dangerous for the population living nearby. Figure 3 shows a coastal landslide on the Ushayka river in Tomsk city, which is very dangerous for the buildings constructed on it. Ravine erosion takes away from production significant areas of agricultural lands. Intensity of ravine growth in Western Siberia varies from weak to strong. As a result of ravine erosion, economic damage for agricultural production reaches 25-30%.

Figure 3. Ushayka bank in Tomsk after heavy shower 17.06.02 (Exogenous, 2003)

The southern area of Western Siberia is most urbanized. Ecological risks here are connected, first of all, with agricultural activities.

Major factors of ecological risks are the mechanical damages of fertile soil horizons, which have two major consequences. First, physical, chemical and biological properties of soils are cardinally changed; second, such processes as wind and water erosion, swamps formation, degradation of flora such as partial or full destruction of separate kinds of vegetation, etc., start to develop actively (Trofimov, 1979). Soils degradation is the reason of decreased fertility of crops.

A large role in ecological risks is played by the ferrous metallurgy industry, nuclear industry and power energetics enterprises, which are located at a southern densely populated industrial zone. Thus, power energetics and ferrous metallurgy enterprises located in the cities of Kemerovo and Novokuznetsk (which are among the leaders in Russia by the air pollution levels), emit into the atmosphere extremely harmful substances - nitrogen dioxide, formaldehyde, carbon bisulphide, ammonia, fluoric hydrogen. The ecological condition of the adjoining territory is extremely bad.

Atomic power stations, research reactors, burial facilities for radioactive wastes, placed on the territory of Western Siberian plain, form the zones of increased ecological risk. For example, an accident at the Siberian Chemical Combine in 1993 resulted in the radioactive nuclide pollution emitted beyond the sanitary zone borders. The pollution area stretched to the north-east direction, in accordance with the wind rose. The area of nuclear pollution with the exposition doze above 30 micro Roentgen/hour was about 50 sq.km. Analyses of snow and soil probes have shown the presence of a number of radioactive nuclides (Ecological, 2001). Pollution, fortunately, fell mainly on little populated territory, covered by forest.

The next factor of ecological risks is presented by large administrative formations located on the territory of Western Siberia – Yamalo-Nenetskiy and Khanty-Manciyskiy autonomous national areas, Altai region, Tyumen, Tomsk, Kemerovo, Omsk and Novosibirsk oblasts. The difficulty in controlling ecological risks consists in complex scheme of responsibility sharing between the federative subjects, as each of the administrative divisions has its own local budget and own ecological normative-legislative base. As a result, it is difficult to calculate ecological risks and to organize the works on the liquidation of consequences of ecological disasters for the entire Western Siberia region.

Another feature of Western Siberia is that natural and weather conditions here are non-favorable for the population. In the north they are extremely adverse. Especially high is the environment impact on the population health, efficiency and specialization of agriculture, technical characteristics of production. In similar conditions even minor changes in the environment quality increase ecological risks several times, in terms of the population health. In Western Siberia, general health of the population, according to many generalized systematic indicators, is poor, which testifies to negative processes in the environment. The medical-geographical analysis of the population disease rates reveals regional heterogeneity: the integrated general disease rate indicators in separate territories

of Western Siberia show 1000-7500 diseases for each 100 000 of the population. The territories with very high disease rate (over 3500) include: Kemerovo oblast, Altay region, Tomsk oblast. These federative subjects belong to the list of territories of high ecological danger (Protasov, 2001). Of all types and classes of diseases, about 20% is connected with environment and its contamination. Table 2 shows connection of environment factors and main diseases on the territory of Western Siberia.

Table 2
The environment factors connected with certain types of diseases in Western Siberia

Class of diseases	The environment factors
Circulation of the blood diseases	Atmospheric air pollution by chemical element. Noise. Composition and rigidity of the drinking water. Territory endemicity on trace elements. Foodstuff contamination by pesticides.
Respiratory apparatus diseases	Atmospheric air pollution by chemical element, dust, sulfur and carbon monoxide. Speed of weather changing. Air pollution by pesticides.
Gastrointestinal diseases	Foodstuff and water contaminations by chemical weed-killers. Territory endemicity on trace elements. Atmospheric air pollution by chemical element, especially sulfur dioxide. Composition and rigidity of the drinking water.
Endocrine diseases	Atmospheric air pollution by chemical element, especially monoxide. Heavy metals pollution.
Blood diseases	Territory endemicity on chrome, cobalt, iron. Foodstuff and water contaminations by pesticides and nitrates.
Allergic diseases	Air pollution. Composition and rigidity of the drinking water.
Skin diseases	Deficit or abundance of trace elements in environment. Atmospheric air pollution by chemical element in combination with natural factors.
Malignant neoplasms	Atmospheric air pollution by carcinogens. Hypertoxicity. Composition and rigidity of the drinking water. High radiation. Foodstuff contamination by pesticides and nitrates.

Tuberculosis rates on the considered territory is 7 times higher that average rates across Russia; the growth of diseases and death rate among children and teenagers is noted; also an essential growth of pathologies is connected with kidney stones, which form due to the polluted drinking water (Ecological, 2001). Essential influence on the growth of disease and death rates is exerted by the pollution of atmospheric air. In Western Siberia, about 4 million people live in conditions of raised concentrations of weighed substances in the air, and 10% of them are affected by the concentrations of harmful substances exceeding maximum permissible levels.

4. Conclusions

Summing up, we can say that the impact on the environment caused by the economic activities in Western Siberia is ever growing and acquiring a threatening character, rendering essential negative influence on natural ecosystems and reducing their natural potential. As a result of unreasonable economic activities, almost irreversible changes of the environment have occurred on the considerable areas, which have caused essential deterioration of the population health, exhaustion of natural and resource potential of the territory.

In order to reduce the negative impacts of pollution on the environment and population health, a scientifically grounded ecological policy is needed, as well as policies focused on health protection and solving of priority problems. First of all, measures must be taken to lower the anthropogenic loads on natural ecosystems, to reveal and analyze the factors of technogenic influence on the

population health. The approach to the solution of problems connected with ecological risks problems in Western Siberia must be based on good understanding of natural complexes functioning on this territory.

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