METHODS AND CRITERIA FOR ASSESSING THE RISK OF SUBSIDENCE PIPELINES IN SIBERIA

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Russian gas pipeline system crosses the areas with different climatic, geological, tectonic, hydrogeological conditions and it is exposed to the negative impacts of different hazardous processes. It means such process which refers to the geological or geotechnical process, that may lead to the violation of the normative status of natural-technical system or its separate parts. Relatively to South Yakutia, there can be meet many dangerous geological and geocryological disasters, such as erosion, swamping, karst, thermokarst, thermal erosion, aufeis formation, bloating, screes, mass displacement of thawed soil on the slopes, etc. [1].

Geohazards presents a separate group of possible threats for the pipeline. Assessment of the risks of dangerous geological situations includes evaluating the likelihood of damaging loads. The differences between «safe» and «unsafe» occasions are related to the stability of the pipeline construction under the load [2]. For instance, first accident will not bring a harm for the pipe, because this geological event can be considering as non-damaging related to the pipeline system. At the same time, other occasion can break integrity of pipeline, which considered as damaging event. There exist distinctions with geological risk estimation for thepipeline.

Absolute susceptibility is case when pipeline system in «safe» condition. It means that nothing happens with integrity of pipeline even under consideration. This situation is possible only if there are no threats or the system has high reliability to resist a stress. However, some elements of pipeline system have less stability than a pipe, that is why some parts should be assessed separately (Fig. 1).

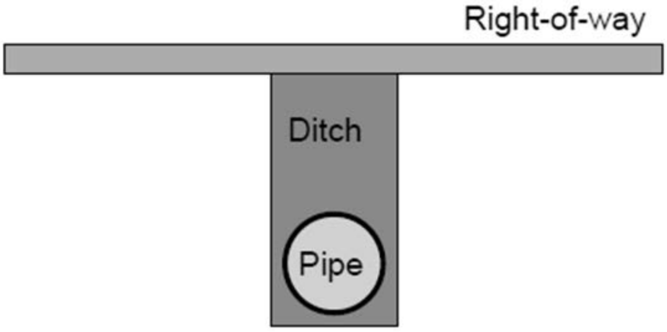

Fig. 1. Pipeline elements

The biggest influence on the pipeline system has the process of surface subsidence. The earth surface subsidence may occur slowly or suddenly because of different causes, for example, removing groundwater or oil (gas), presence of sinkholes, underground working, destruction of permafrost and so on. Land subsidence does not mean only a downward movement. Down motion may be accompanied by side movement vector of the soil. Both of movement can be the reason of negative impact on pipeline and it may create big risky compressive stress and disrupt the stability of structures. This deformation of land surface can occur in the form of bending, tilting, and the precipitate or in the form of soil drop. The table, which was mentioned below (Table 1), shows the list of geohazards and their effects on a pipeline system.

Table 1

List of hazards and their influence on pipeline system

Disaster	Effects	Elements affected (directly only)		
		Pipe	Ditch	ROW
Thawing of permafrost under the pipe	Can be the cause of thawing pipe, as a result pipes deform, because of pipe bending in areas of cavities	Yes	No	No
Thawing of ice-rich backfill	Increasing a chance of pipe destabilization, displacement because of erosion along ditch	No	Yes	No
Thaw ROW	May be the cause of drainage violation because ground subsidence	No	No	Yes
Ground shaking	Increasing dynamic strain on pipe	Yes	No	No
Colliquation of soil	Decreasing strength of earth accompanied by soil movement	Yes	Yes	Yes
Water scour of soil	Over the pipe occurs hydraulic erosion of the material	Yes	Yes	No
Sinkhole development (karst)	Below the pipe occurs possible pipe deformation depending on size and depth of sinkhole	Yes	No	No

This list shows only a part of all possible geohazards which can be the cause of pipeline subsidence. The table is evidence of consequences severity for the pipeline system. To avoid all these disasters, it is necessary to evaluate risk in order to predict and eliminate problem before it is happened. Risk assessment is the procedure of quantitative estimation the danger which is related to a certain situation and was defined as a threat. This process has two specific moments. The first determines the likelihood of risk frequency, the second one – identify the influence of the risk, i.e. severity of consequences [3]. Generally, risk management process consists from the following steps:

1) Risk management planning. The step is responsible for determination the impact of hazard and planning of future events;
2) Risk identification. The purpose of it, to provide an examination of issues;
3) Qualitative and quantitative risk analysis. This step assumes analysis of charts, graphs and other data;
4) Risk response plan. The meaning of the point to create solving plan and fix the problem;
5) Risk monitoring and control. The step in charge of quick response for after the intervention.

Often, the method and criteria which were mentioned above, is not enough to predict subsidence of the earth's surface with sufficient precision. In this case, it is necessary to use additional parameters of the rocks, their tectonic fractures, morphometric characteristics of the relief, physical and mechanical properties of soils, groundwater characteristic and so on. The next method is suggested to consider widespread geological indicators which are quite common in karst research. Usually, they use the list consisting of 21 parameters separated into 6 groups [4]: structural-tectonic, geological, hydrogeological, geomorphological, engineering-geological and geocryological (Table 2).

Table 2

List of criteria to assess the risk of surface subsidence

Group	Parameters
Structural-tectonic	Linear density of lineaments Ll, 1/km^2
	Number of intersections of lineaments Ml,amount/km^2
	Modularity Bl, km^2
	Distance from lineaments Rl, m
Geological	Power of loose quaternary rocks
	Power of peat
	Composition of bedrock
Hydrogeological	Depth establishing of groundwater HQ, m
	Depth establishing of the fissure-karst waters Hk, m
	Salinity of groundwater M, g/dm^3
	Hydrochemical facies of groundwater
Geomorphological	Slope of the terrain β, degree
	Distance from river U, m
	Slope of catchment tg α, u. f.
Engineering-geological	Density ρ, g/cm^3
	Module total deformation of the soil cover thickness E_0, MPa
	Internal angle friction of soil cover thickness φ, degree
	Specific cohesion of the soil cover thickness c, kPa
Geocryological	Soil temperature T, °C
	Ice content i_{tot}, u. f.
	Total humidity W_{tot}t, u. f.

One of the most important factors in the development of subsidence is a geological structure of the area, which means the material composition of soluble rocks; its textural and structural features; the content and composition of insoluble residue; the composition, structure, power, and nature of bedding layers, the genesis and age of karst rocks. Karst is dangerous especially because of possible underground cavities, which are sometimes difficult to engineering geological assessment and potential threat for pipeline system.

The methods which were described in this paper and criteria for the assessment of surface subsidence can be used to predict and monitor the occurrence of surface subsidence and protect the pipelines from their negative impact. Studying of the influence of natural factors on the stability of pipelines in karst areas is of big significance for the development of the oil industry on geological difficult territories and it is attracted investments in high-tech industry. In conclusion, analyzing the methods and criteria of risk assessment that were mentioned in this article, we can say that complex approach is the best way to solve the problem and it will ensure optimal results and effective monitoring of pipeline accidents.

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COLLOID TRANSPORT OF PLUTONIUM IN WATER BODIES IN THE SEMIPALATINSK TEST SITE

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The consequence of nuclear power facilities operation, accidents at nuclear fuel cycle enterprises, nuclear weapons tests was result of the presence in the environment of technogenic radionuclides, particularly transuranic isotopes, which are able to make a substantial contribution to the total radioactivity of natural objects [1]. It is necessary to take into account the duration of transuranic elements decay, the half-life of them reaches dozens of thousands years, and exposure to biosphere very long time.

The actual rate of migration such elements as Pu, Am, Eu, etc. with groundwater significantly higher than the predicted using thermodynamic calculations that took into account sorption on host rocks, complexation in solution and the formation of slightly soluble compounds [1, 22]. In [4, 8] it is emphasized that the description of plutonium migration with groundwater is not possible without considering the contribution of the colloidal particles in the process. Colloidal particles are essential to mobility of radionuclides in groundwater and surface systems, but systematic research of physical and chemical forms of the actinides in natural waters quite a bit.

Underestimating the "colloidal transport" mechanism of these radionuclides has resulted to mistakes in the calculation of the plutonium migration rate in groundwater at the Nevada Test Site [3, 5]. Despite the significant role of colloids in the migration of some radionuclides, yet there is no a unified model of migration behavior of radionuclides, which takes into account the role of colloidal particles [4, 6, 10]. Scientists in this field highlights the lack of reliable experimental data (both real and for model systems), as well as the lack of understanding of the mechanisms of formation of stable colloidal particles and regularities occurring on their surface sorption reactions [4].

In the 2000s, the fragmentary studies of radionuclide content and form of their occurrence in water bodies of the Semipalatinsk test site within the various programs and projects were carried out [9, 12].

The authors studied the radionuclide content and forms of occurrence of plutonium and uranium in well water of the village "Sarzhal", located near the borders of the nuclear test site, wells of wintering in the "North" part of the Semipalatinsk test site; stream Uzynbulak, Shagan River and lakes Telkem-1 and Telkem-2 [9]. They distinguish the following forms of speciation: suspended matter, oxidized forms of uranium and plutonium (oxidation state +5, +6, total), reduced forms of plutonium uranium (oxidation state +3, +4 and total) by the method "limited iron" technique and sequential precipitation reduced and oxidized forms. According to the authors of [9, 12] in the water from funnel of explosion "Telkem-2" from 89 to 98% of plutonium was in a state of Pu (III, IV), the remaining part, they believed, was in a state +6. High proportion of reduced forms they associated with the presence in water a large amount of dissolved organic matter.

The reports of of the Radium Institute named Khlopin has unpublished research (2006) under Professor Y. Dubasov, where they studied the water of the tunnel creek an object D2 territory of the ground "Delegen". It was found that the percentage of plutonium in a fraction of the pseudo-colloids is between 9 to 20%, the proportion of plutonium in the +6 state ranged from 7 to 11%. The main plutonium fraction (70-80%) is in form Pu (III, IV).

The aim of this work is the study of the speciation of plutonium in the water bodies of the Semipalatinsk test site.

The selection of the objects for the study of the forms of radionuclides in the water is based on literature data on the content of radionuclides in the water bodies of the Semipalatinsk Test Site [1]. The objects of this study were watercourses of portal areas of tunnels 176, 177, 503, 504 and 511 at "Delegen" ground of the Semipalatinsk Test Site.

The volume of water samples ranged from 2 to 10 liters. The water sample was collected into clean polyethylene containers, avoiding stirring up of sediments and inclusion any extraneous impurity, and then filtered through a cellulose filter with a pore diameter of 5-8 microns on place or within 24 hours of sampling in the laboratory.

Then, the sample was divided in two parts, one part of the sample was acidified and concentrated with nitric acid to pH = 2 and co-precipitation of iron hydroxide was carried out. Another part was filtered through a membrane polyethylene terephthalate filter with a pore diameter of 0.2 microns, permeate was acidified whereupon added isotope tracers and concentration in a similar way was carried out. Thus, this sample preparation allowed arbitrarily distinguishing the following forms of occurrence: "suspended matter", "colloidal substances" and "true-soluble form".

Basic parameters of the tunnel water streams "Delegen" test ground composition are presented in Table 1.

According to the general chemical composition, tunnel streams are predominantly fresh and slightly mineralized waters (Tun. 504), in anion-cation composition – for tunnels 176, 177, 511 watercourses bicarbonate and calcium ions are dominant, and for tunnels 503, 504 streams dominant ions are potassium, magnesium and sulfate.

It has been established that plutonium activity in the studied water bodies ranged widely – from $n \cdot 10^{-2}$ to $n \cdot 10^{0}$ Bq/l (Table 2).