



## **Environment consequences of accident launch vehicle falls**

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The regular operation of space activity is accompanied by a slight impact on the environment. Accident falls of launch vehicles result in the most negative and vast degradation of ecosystems.

The purpose of the study is to characterise the consequences of the accident falls of the launch vehicle (LV) Proton, occurred between 1999 and 2016, for the arid ecosystems in Central Kazakhstan.

Explosion and destruction of the first stage of the launch vehicle Proton resulted in mechanical and pyrogenic disturbances and chemical pollution of ecosystems, which is determined by the number of the propellant components residues and the nature of the destruction of the first stage. If the launch vehicle Proton explodes during the landing, propellant components are burned out, and only zones of mechanical and pyrogenic effects are observed. In case the LV Proton does not explode during the landing, pollution by hazardous materials occurs too.

The remarkable environment impact is typical for remediation process. Topsoil horizons are ploughed and excavated when funnels and embankment are evened. Moreover, a zone of mechanical disturbances is expanded. Special solutions used for extinguishing the fire and neutralizing toxic propellant components reduce the concentration and toxicity of propellant components in soils but pollute the environment too. At the same time, the chemical composition of the soils changes because new chemical compounds are entered and microbiota is affected. In addition, using of a large volume of aqueous solutions during remediation process result in the migration of hazardous materials to subsoil, where they can persist for a long time. Geochemical transformation of the soils in the launch vehicle falling sites resulted from mechanical and chemical disturbances defines changing in vegetation cover.

The comparative analysis of various emergency situations occurred during the LV Proton launching made it possible to assess the scale of the environment impact and recommend the most suitable methods for remediation of the disturbed area in Central Kazakhstan.

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