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INTEGRATED APPROACH OF THE RISK AND ENVIRONMENTAL IMPACT. CASE STUDY – PREREQUISITES OF A NATECH EVENT AT A NATURAL GAS COMPRESSOR STATION

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ABSTRACT. The scope of the study which lies behind this paperwork is to emphasize the importance of integrated approach of risk and environmental impact, previous to and/or during the performance of an industrial activity. The case study analyzes gas compressor station located in an area that is subject to landslides. The geomorphologic risk analysis employed the methodology of the GT 019-98 standard. The outcome of such methodology has materialized in the elaboration of a risk map showing an average to high risk probability of landslide in the area where the compressor station is located. In order to assess the environmental impact an assessment matrix was applied, which shows that the activity at the location has significant impact on environment and on the people's health and safety as well as on the land instability.

Further to the integrated approach of the risk and environment impact an overall perception on the current environment issues from the location was outlined, and the importance of elaborating a NaTech type risk analysis for any industrial objective from the design phase was emphasized, providing the conditions for alignment to the sustainable development concept.

Key words: *NaTech risk, landslide, natural gas, environmental impact.*

AIMS AND BACKGROUND

Natural disasters may affect chemical plants and critical infrastructure such as refineries, oil and gas storages, gas and oil transmission pipelines (Krausmann et al., 2011a). Thus, natural disasters may lead to major industrial accidents, referred to as NaTech accidents (NAtural hazard triggering TECHnological disasters) (Krausmann et al., 2011b). NaTech disasters may have major negative impact on industrial locations which hold hazardous materials, oil and gas pipelines and on security systems which could result in serious adverse effects on population and environment (Young et al., 2004), especially for communities that are not prepared to cope with disasters of such magnitude (Ozunu et al., 2011).

Landslides are displacements of rock bodies on slopes (mountains, hills, sides of reclaims or other land development) (Grecu, 2006), caused by natural factors (seismicity, rainfall intensity, erosion, etc.) or anthropic factors (slope digging, deforestation, vibration – as in case of industrial units) (Andersson-Sköld et al., 2013).

This study refers to a gas compressor station affected by landslides which runs at Natech type risk. The situation presented in this paper emphasizes the importance of integrated risk approach and environment impact, both during industrial activities as well as before installing it, in order to avoid potential NaTech type events.

Therefore, the scope of this study is to demonstrate that NaTech risk analysis has to be one of the main factors in achieving any industrial site from the design phase, so providing the conditions for a sustainable development. Moreover such analyses should be updated periodically in order to make the adequate preventive measures to reduce significantly the risk of NaTech accident during the operation on site.

DESCRIPTION OF CIRCUMSTANCES

The compressor station is located on top of a hill with N-NE and S-SW slopes, with unstable land (landslides with land rupture) due to geological substrate and specific climate conditions.

Due to occurrence of instability phenomena which could affect the compressor station location, the N-NE slope was consolidated by drilled pillars built in reinforced concrete girders. After performance of land stabilization works on this slope, the land displacement trend was stopped.

The conclusion following the field survey was that S-SW slope is not consolidated, slope that shows multiple ruptures generated by landslide (figure 1). These ruptures modify their size and form continuously and result in continuous land displacement. Therefore, currently, there is no natural trend of land stabilization on this slope.

Fig. 1. *Landslide in the proximity of the compressor station*

GEOMORPHOLOGIC RISK ASSESSMENT - METHODOLOGY

Landslide hazard probability map is an important instrument in geomorphologic risk assessment of a territory. Thus, we intended to elaborate such a map in the context of our study, subject to Regulations GT 019-98: “Guide for elaboration of slopes landslide risk map for constructions stability”. We also used for elaboration of this map geological, geomorphological, structural, hydro-climate, hydrogeological, sylvan, seismic and anthropic documents and maps.

The indices for calculation of coefficients were estimated according to the methodological guide.

Calculation formula for environment risk coefficient is the following:

$$K_m = \frac{K_a \cdot K_b}{6}\left(K_c + K_d + K_e + K_f + K_g + K_h\right)$$

where: K_a = lithological criterion, K_b = geomorphological criterion, K_c = structural criterion, K_d = hydrological and climate criteria, K_e = hydrogeological criterion, K_f = seismic criterion, K_g = sylvan criteria; K_h= anthropogenous criteria.

For the geomorphological criterion, in compliance with GT 019-98 regulation, the following have been considered: slope (K_{b1}), display (K_{b2}), depth of relief fragmentation (K_{b3}) and horizontal relief fragmentation (K_{b4}).

The landslide hazard chance map includes the following probability classes: zero, small, medium, and medium to high, high, very high.

GEOMORPHOLOGIC RISK ASSESSMENT - RESULTS AND DISCUSSIONS

The landslide hazard map was drawn in compliance with the above mentioned methodology for the compressor station area, considering the regional context (figure 2). The risk was plotted for the 6 probability classes, from minimum to maximum. Thus, as shown in figure 3, the land where the compressor station is located corresponds with a medium to high probability of landslide.

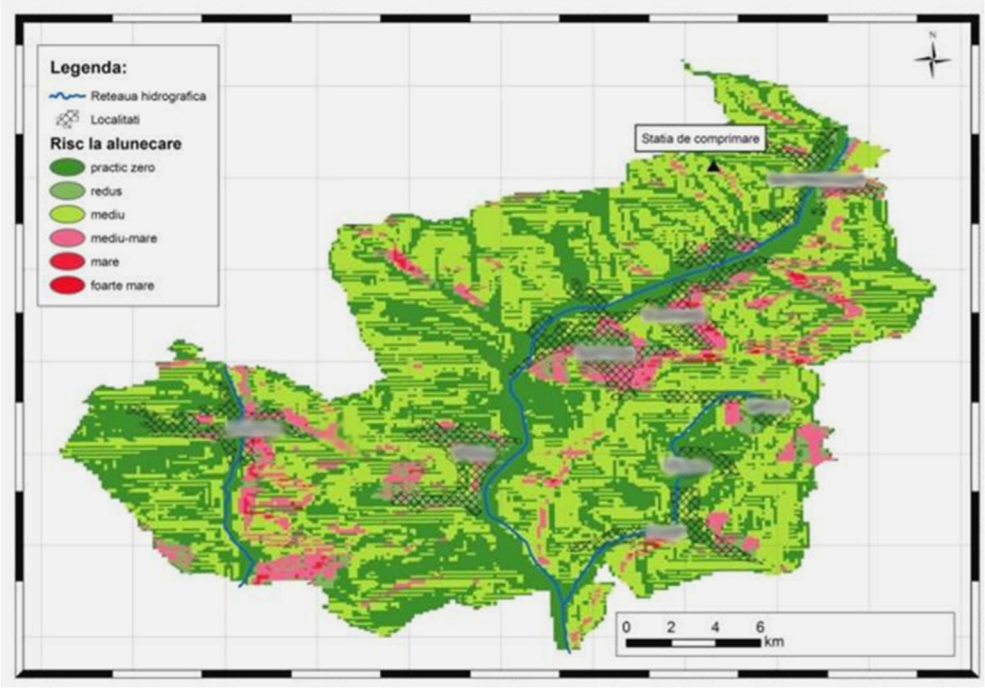

Fig. 2. *The landslide hazard map in the area of the compressor station*

ENVIRONMENT IMPACT ASSESSMENT – METHODOLOGY

Assessment of anthropic impact on the environment due to compressor station activity was performed on the basis of RIAM – Rapid Impact Assessment Matrix elaborated by Pastakia and Jensen in 1998 (Pastakia and Jensen, 1998).

The assessment was based on data and information, bibliographic information and field surveys which increased the assessment objectivity. The method and the matrix components have been adapted according to considered specific characteristics of the area under study and its social-economic significance

ENVIRONMENT IMPACT ASSESSMENT – RESULTS AND DISCUSSIONS

The assessment matrix (table 1) shows that the impact on natural components and on economic and operational components has been evaluated to a score of -163 which means a major impact.

Table 1. *The general impact assessment matrix on the environment in the area of the compressor station*

Environment components	A1	A2	B1	B2	B3	**SE**	CI
Natural components (biotic and abiotic)							
Geological substrate/mineral resources	3	-2	3	1	2	**-30**	-B
Soil	1	-1	3	1	2	**-6**	-A
Land morphology	1	-1	3	3	2	**-8**	-A
Underground waters	1	-2	2	2	2	**-12**	-A
Surface waters	1	-1	2	2	2	**-6**	-A
Air quality	1	-1	2	2	3	**-7**	-A
Microclimate and topoclimate	1	1	2	2	2	**6**	-A
Torrential/linear erosion	1	-1	1	1	1	**-3**	-A
Sedimentation/silting up	1	-1	2	2	3	**-7**	-A
Land stability	2	-2	3	2	3	**-32**	-B
Grass	1	-1	2	2	2	**-6**	-A
Birds	1	-1	1	1	2	**-3**	-A
Animals living on the ground and reptiles	1	-1	1	1	2	**-3**	-A
Insects	1	-1	1	1	1	**-3**	-A
Assessment score						**-120**	**-E**
Economic and operational components							
Human health and safety	1	-3	3	3	2	**-24**	-A
Unemployment rate	1	1	1	1	1	**3**	A
Anthropic structures	1	0	1	1	1	**0**	N
Transportation networks	2	0	2	2	2	**0**	N
Utility networks	2	1	2	2	2	**12**	+A
Waste disposal	1	-1	2	2	2	**-6**	-A
Oil collecting tanks	1	-1	2	2	2	**-6**	-A
Discharge separators	1	-1	2	2	2	**-6**	-A
Compressed gas cooling towers	1	-1	2	2	3	**-7**	-A
Technological manifold of the compressor station	1	-1	2	2	2	**-6**	-A
Assessment score						**-43**	**-B**
Total assessment score						**-163**	**-E**

Natural components are subject to major negative impact (-120); the most affected environment characteristic is land stability.

Impact over the *economic and operational components* is negative (-B) with an environment score of -43. The most affected components of all are human health and safety.

CONCLUSIONS

The risk and environment impact integrated approach at the gas compressor station indicates that compressor station location is in an area prone to landslide and therefore it is subject to a NaTech risk which could result in events with severe consequences. This situation could have been avoided if NaTech risk analyses had been performed before construction.

Operation under current context of the compressor station in an area with medium to high landslide probability could generate NaTech accidents; therefore an analysis should be performed at the location to assess the risk related to operation safety.

The presence and operation of the compressor station itself has negative impact on natural, economic and operational components which influence the emergence of NaTech risk. Mitigation of this impact might be achieved by implementation of BAT (Best Available Technologies).

Due to the obvious trend of development of the landslide and because there is no natural trend of land stabilization, two options should be analyzed: land stabilization or relocation of the station in a nearby area which is not affected by landslide. Such decision should be based on “lessons learned” from other accidents of the same kind, by consulting available libraries on this matter. Initiating a campaign for public awareness and information on the risk and severity of NaTech type accidents should be a priority of the risk management.

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