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TAXONOMY AND "VULNERABILITY" OF THE GEOENVIRONMENTAL RISK PROCESSES AND SOME INDUSTRIAL FACILITIES TO THE INTENTIONAL ACTIONS (intacts)

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ABSTRACT. The presented taxonomy is classifying (quantitatively and qualitatively) the different natural hazardous processes and their "vulnerability" to the human activity and possible intentional actions (intacts). Due to the increased threat from different actions (including terrorists), which can generate different negative consequences to the society and the economic development, such taxonomy can serve to the decision and policy makers for the risk management, response actions and prevention and protection measures. The taxonomy arranges the different types of the natural hazards (in the solid earth, water or air), to the susceptibility to intentional acts, etc. The special attention is paid to the different phases in which the geoenvironment exists (calm, activated, critical) and the actions which could be applied during these stages. Same approach is applied to some heavy industrial facilities. Different preventive and protective measures are indicated in a very general aspect. The framing of such hazardous events is of a high priority in the EC security policy.

ТАКСОНОМИЯ И УЯЗВИМОСТ НА РИСКОВИ ПРОЦЕСИ В ГЕОЛОЖКАТА ОКОЛНА СРЕДА И НА НЯКОИ ИНДУСТРИАЛНИ СЪОРЪЖЕНИЯ ОТ ПЛАНИРАНИ АКЦИИ

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РЕЗЮМЕ. Представената таксономия е първи опит за класификация (качествена и количествена) на различните природни опасности и тяхната уязвимост от човешка дейност, и възможни планирани акции (тероризъм). Подредбата е направена за различни природни опасности, които могат по един или друг начин да бъдат "задействани" и да предизвикат тежки за обществото последици. Класификацията е направена както по място на проява (твърда земя, вода и въздух), така и по отношение на чувствителността на всяка природна опасност към планирани акции, очаквани негативни последици и други параметри. Специално внимание е отделено на различните фази, в които се намира околната среда (спокоен, активен, критичен период. Дефинирано е понятието "медиатор" като трети елемент (освен първите два – планирана акция и стартирало бедствие), пренасящ критична част от енергията, необходима за стартиране на процеса на бедствието. Подобен подход е използуван и за тежкоиндустриалната инфраструктура на добивната, преработващата и енергийна система. Предложени са различни мерки за защита и снижаване на опасността в обобщен вариант. Рамкирането на подобни опасности е поставено като приоритет в Европейската Комисия поради нарасналата опасност от терористични акции от всякакъв характер.

Introduction

Usually the society imagination about the terrorist actions is targeted to the man made facilities and infrastructure. The last 10-20 years activity of the different terrorist groups, strongly support this imagination – 11th September action, Persian gulf boat action, Tokyo metropolitan gas attack, Madrid 11th March attack and many other examples look like supporting this issue. But there are some dangerous natural phenomena, which also can be used for panic creation, human deaths and property losses. There are some possibilities to affect some natural hazardous processes, thus generating hazard environment and risk effects to the population and the social infrastructure. Such actions prepared by some people to affect the natural hazard environment, usually needs more knowledge, time and resources to be effective. According to this view we called these actions, not simply "terrorist", but intentional, because the difference is significant and the abbreviation "INTACTS" is accepted. There are also many examples, when the human activity has triggered different natural phenomena – earthquakes (so called induced seismicity), landslides, rock bursts (as a result of mining activity), floods and mudflows (dam and dyke breaks), forest fires, tsunamis (generated by big blasts), even the volcanic eruptions. Up to now only military programmes have been developed focussing on these aspects (Portalsky, 1983), but due to the increased activity of the terrorists, these topics are under consideration now in the civil science as well.

Examples on triggering natural hazards by transmitting agent (mediator)

The active treatment of the weather (for example) has been performed in many countries by different chemicals (mostly AgJ dispersed by rockets) on the clouds against the hails. During the last several years in connection with the pit burns around Moscow, a message for an active treatment on the clouds for triggering rain have being announced, etc.

For the solid earth hazards a large military program in the former USSR has been developed for inducing earthquakes at the larger distances, based on seismic ray emission theory. A set of seismic heavy vibrators has been deployed all over the territory of the former USSR to try to trigger a strong earthquake to far field faults (for example - San Andreas fault). The theory was well developed and several experiments applied. No significant results have been reached (the energy for the vibrators action is too large and expensive in comparison with the results expected) that's why, after the

"perestroika" period this program has been cancelled. In the USA so called Denver swarm was announced, when injecting the water in the old exploitation boreholes the swarm of weak to moderate earthquakes have been triggered, observed and registered. All nuclear underground explosions at the Nevada test-site have been accompanied by the aftershocks (good descriptions and examples in the B.Bolt book "Nuclear explosions and Earthquakes"). Well known are the cases of triggering earthquakes after the fulfilment of the big reservoirs and dams. (Gupta, 1982).

Very often different poisons are used for the soil and water contaminations. Frequently reported by the mass media Hg spots on the ground are mostly used as panic creator, because of the strong poison effects of this substance generated by vapours, liquid or solute phases of this agent. This substance can be easy obtained and spread on the land and underground waters, but the neutralization is also easy.

In the water, tsunamis have been successfully generated after the underwater nuclear explosions on the test-sites at Murooa and Bikini atolls during the mid 60-ties to 70-ties of the last century (Murthy, 1986), as well as by the chemical explosions in the Dead Sea during 1999.

Possible triggering effects could be expected by big blasts (bombing) on active or activated volcanoes.

So, still the possibilities for an active influence on the natural hazards are very limited, but for some of them such possibilities exist and can be used for intacts and the negative consequences, which they can produce, must be considered.

Table 1.
Taxonomy of the natural hazards during the different stages of existence and the possible " mediator" us" for the intacts:

Stages	calm	activated	critical	post event
Processes				
Solid Earth events				
Earthquakes	no	no	big blasts/water	blasts/fire
Landslides	no	water	water/vibrations	water
Volcanic eruptions	no	big blasts	big blasts/water	collapse/lava/ash
Rockfalls	no	vibrations	vibrations	no
Mudflows	no	water	water/vibrations	water
Slope processes	no	no	water/vibrations	no
Caves	no	blasts	blasts/vibrations	no
Mines (old or recent)	blasts/water	blasts/water	blast/water/gas	no
Rock bursts	no	blasts	blasts	no
Erosion	no	no	water	no
Soil pollution	no	no	chemicals, Ra-active substances	poisoned people
Water connected events				
Floods	no	water	water/blasts	no
Tsunamis	blasts	blasts	blasts	no
Meteo events				
Storms	no	no	no	no
Heavy rains	no	no	chemicals	no
Icing	no	no	water	no
Tornadoes	no	no	no	no
Hails	no	no	no	no
Mist (Fog)	no	no	chemicals	no
Forest fires	fire	fire	fire	fire

The Mediator

There is a very specific element for all these intentional actions. To perform such activity one must be well educated and equipped and to know the "sensitive points" of each natural hazard to be able to make an effective action. Usually the natural phenomena can not be triggered directly by the direct human action. In the most specific cases (so called "unstable/critical conditions") such possibilities exist by using some kind of a transmitting agent. Most frequently a transmitting agent (called further mediator) can be used to trigger a dangerous natural phenomena – for example blast, fire, water mass (ice, snow) movements, etc. It is visible that to trigger a natural hazard event, so called mediator agent is necessary to be used. It is called furthermore – the "third agent" or mediator.

Natural Hazards vulnerability classification

The natural hazards could be divided into several types, but the most useful for this study purposes is the classification done by Brouchev at al. (1995), because is considering the time dependence of the different hazardous events and processes:

A) Processes of sudden action and repeatability caused risk consequences: earthquakes, landslides, rockfalls, mudflows, tsunamis, induced seismicity,

avalanches, subsidence, floods, storms, hails, icing, rock bursts.

B) Processes with permanent action: erosion, abrasion, silting, weathering, soil salinization, screes, etc.

C) Processes with permanent action leading to the sudden risk effects: loess collapsibility, underground erosion (suffusion), liquefaction, karst and caves, mud volcanoes, etc.

Summarizing the sensitivity to all stages of the natural phenomena development and the intact activity the Table 2. for the Natural risks and their "vulnerability" to intacts is created.

The short description of the produced effects as described in Kovachev et al., (1995) is included as well. Table 2. is created to present the possible "vulnerability", the level of the possible negative consequences (the scale of the different events) and the "effectiveness" of the intacts (in terms of costs) classified from the point of view of possible intacts influence. The negative consequences are also taken into account.

Table 2.

Comparability of the Natural Risks and their "vulnerability" from intacts

Processes	Effect	Vulnerability	Expected negative consequences	Effectiveness of the intacts
Solid Erath events				
Earthquakes	vibrations	very low	high	very low
Landslides	mass movements	low	high	low
Volcanoes	heat/mass mov.	low	high	low
Rockfall	mass movements	high	middle	middle
Mudflows	mass movements	middle	middle	low
Avalanches	snow movements	high	high	high
Slope processes	mass movements	high	high	very low
Caves	collapse	high	middle	low
Underground mines (old or recent)	collapse	middle	high	high
Open mines (old or recent)	mass movements	low	low	middle
Rock bursts	collapse	low	middle	middle
Erosion	mass movement	low	low	very low
Soil pollution	pollution	high	middle	high
Water connected events				
Floods	water movement	high	high	high
Tsunamis	water movement	middle	high	high
Meteo events				
Storms	wind, rain	very low	high	very low
Heavy rains	water level	very low	high	very low
Icing	ice	very low	high	very low
Tornadoes	high winds	very low	high	very low
Hails	ice, rain	low	high	very low
Mist (Fog)	air effects	low	low	low
Forest fires	fire	high	middle	high

Scales applied to the Table 2

Vulnerability

Very low – practically impossible to trigger such event, but the threaten can be used for panic creation or rumours spreading (for example - earthquake, storm, icing).

Low vulnerability – possible in very rare cases and circumstances to activate the process (for example landslide, fog).

Middle – possible, but needs special and complicated organization (for example - local tsunamis, mining storage destruction).

High – easy can be activated or triggered (for example: floods (by destruction of dykes), avalanches, rockfalls, cave collapse, mining objects, oil and gas boreholes and facilities).

Level of negative consequences

High – very dangerous in case of a big magnitude event.

Middle – dangerous for some facilities and the affected people.

Low – not dangerous directly for the facilities and population.

Level of the "effectiveness" of the intact

Very low – the cost of the preparation and execution is much bigger then the cost of the produced consequences.

Low – the cost of the intact preparation and execution is bigger then the cost of the consequences.

Middle - the cost is approximately the same as the cost of the consequences.

High - the cost is less that the cost of the consequences.

The analysis

The analysis of the upper tables (1 and 2) shows some specific peculiarities. Usually, when the preparation time of the process is long and needs hard preparation and huge expenses for

intact, the effectiveness is low or very low. This means that it is much less probable such natural hazards to be triggered by intacts. Again the focus of the high effectiveness, could be found around the hazard processes which are due to the human impact in the activated and critical stages (for example – landslides, rockfalls, avalanches and other slope processes). For some other processes the effective intacts can also be applicable, (gas and oil fields, old and recent mines, etc.). Only for tsunamis and partially for the soil contamination there is no difference between calm (latency), activated and critical phases. This means that it is much easier to protect the places when such phenomena exist, because it is very difficult to organise and implement such intacts in this environment. It's clear as well that this taxonomy could be applied on the local and regional level, in dependence of the natural phenomena coverage. Frequently small area hazards could bring more negative consequences, then larger ones and it depends on the vulnerability of the threaten facilities and the magnitude of the triggered event. The post event hazards must be also considered in some specific cases, especially for the high level dangers, because of the secondary or domino effects (Lessons learnt – Reports, 2000-2003).

Protection and prevention:

Some protective measures

Activities to mapping, monitoring and investigations of the intensity and the volumes of the natural processes and events, which can be threatened by intacts must be performed. The all stages of the hazardous phenomena must be identified in time and space. Access to the transmitting agents during the dangerous stages must be limited by the specialized regulations. Correct information to the threatened population about the intacts possibilities must be disseminated to the public. Emergency plans and actions must be foreseen for the specialized units of Civil defence. Training activities of the responsible institutions - civil defence, local authorities and the population must be planed and performed. Frequently the data and information international exchange could be useful about such activities.

Prevention

Regulations must be created classifying the intact possibilities to trigger the natural hazards, including vulnerability, third agent (mediator) abilities, possible intacts performance, prevention protection and people preparation.

Measures preventing the activation of the processes have to be performed for prevention when it is possible.

All regulatory mechanisms and access to the possible third agents (mediators) must be formulated and applied by the specialised authorities.

Correct information disseminated among the population has to be done. Emergency plans considering such possibilities of the intentional acts must be created. Training courses for the decision makers and the Civil protection authorities have to be performed regularly.

Taxonomy on the vulnerability of some industrial critical facilities to the intentional acts

The much more vulnerable to the intacts are the facilities of industrial and supplying infrastructure, connected with the exploration, exploitation and the use of the natural resources. They are more vulnerable to the different sabotages. Most of them are presented at the following table. Not only the facilities are taken into consideration, but also the negative consequences, which they can produce. The last ones are divided into two categories – social and economic, which are considered equally important. This means that in some cases the effects of the intacts are comparable in the social and economic aspects, which is an important topic for the decision makers. The taxonomy shows the vulnerability in qualitative aspects, and for the quantification, many new data and methodologies have to be applied.

Due to the rare time of occurrence of such activities, it is really a problem to collect the relevant information for such intentional actions. There is another factor, which must be taken into consideration – very rare the intacts are applied on one and the same type of facilities, because the measures are taken afterwards.

So the lessons learnt can help the decision making process in some cases, but also the modeling and the scenarios development could be applied for the better management. The table is not complete, but considers the most frequent facilities used in the EU, which could be threaten by the intacts. The most vulnerable and dangerous chemical plants for example, are not included, because they are under the SEVESO directives and have special almost unified protective measures.

Table 3.
Comparability of the different facilities and their vulnerability (in average) to intacts

Facilities	Vulnerability from intacts	Negative consequences	
		Social	Economic
Dams	middle	massive	heavy
Dykes	high	middle to strong	middle
Bridges	high	middle to strong	middle
Roads	low	middle	low
Railways	high	middle	middle to heavy
Refineries	middle	middle to strong	heavy
Pipelines	high	middle to strong	middle to heavy
Electric lines	high	middle	middle
Power stations	middle	middle to strong	middle to heavy

NPP's	low	strong to massive	heavy
Mines	middle	isolated to middle	heavy
Waste storages	low	isolated to middle	middle
Exploitation boreholes	low	isolated	middle
Oil and gas sea platforms	middle	isolated	heavy
Gas and oil stations	high	middle to strong	middle
Tunnels	low	middle	middle to heavy
Metropolitans	high	middle to strong	middle to heavy
Ports	low	middle	middle
Tankers (boats)	high	isolated to middle	middle to heavy
Factories (chemical, etc.)	middle	middle	middle to heavy
Blackouts	middle	middle	middle to heavy

Scales applied to the Table 3

Vulnerability:

Low – means resistant structures, and huge difficulties to organize a teract.

Middle – means difficulties to organize a teract.

High – means to organize and perform the teract without significant difficulties.

Social consequences:

Massive – affects a lot of population.

Strong – affects many people (hundreds of people).

Middle – affects several people (tens of people).

Isolated – affects few people.

Economic consequences:

Heavy – destruction difficult to rebuilt or repair.

Middle – destruction repairable for few months.

Low – destruction easy to repair.

Analysis

As it is shown on Table 3, the different facilities have different vulnerability to the intacts. In this table only some heavy industry facilities are included and the list, of course, is incomplete. Frequently a single industrial facility can trigger cascading ("domino") effects (single or several) of other negative processes and consequences. For example: a dam brake, can create flood, brake the bridges, or trigger landslides, rockfalls, tsunamis or sometimes mining collapses. Usually such multiple events disconnects almost all life-lines – roads, electricity and water supply, leads to gas and oil isolation (leakage) and/or the disturbances to the communication lines. This means that these facilities are secondary generators of the "domino" effects and cascading cases.

Some protective measures

The important problem for such critical man-made facilities is to go deeper and to outline the weak points of each facility, for the better security of it. Security systems (autonomous or watched for monitoring and observations) have to be established around the threaten facilities. The proper education system about specialized guards, decision makers and working people in the facilities has to be developed. Special constructive measures against intacts could be performed in advance.

Preparedness and Prevention

Correct information disseminated among the possible threaten people and the population is essential. The emergency plans creation must include as well as the measures against these similar threats. Training actions for the decision makers and the threatened population, must be performed regularly including lessons learned by previous events (if any), or to model the effects of possible scenarios. The training of the security personnel is also essential, because of the peculiarities of the threaten facilities, possible triggering effects and considering the possible "domino" effects as well as the NATECH (NAtural disasters Triggering the TECHnological ones) and possible vice-versa – (Technological – triggering some Natural disasters) scenarios.

Conclusions

The useful classifications and taxonomy about the "vulnerability" of the natural risk processes to the intentional actions and human activities is prepared. Same approach is developed for some industrial facilities as well. Both classifications can serve the decision makers (Tenekidjiev et al. 2001, Tenekidjiev et al., 2003) to choose the optimal decisions about the people and/or infrastructures vulnerability, safety and protection by different measures. This taxonomy is useful as well for the risk control measures which could be applied by the respective authorities, to be included in the emergency response plans, risk maps or on other risk management activities.

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