CRITERIA USED TO IDENTIFY THE RISKS OF MAJOR ACCIDENTAL POLLUTION FOR THE WATERS OF THE TAILING DAMS IN ROMANIA

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Abstract
The implementation of the recently amended Seveso II Directive, which relates to the prevention of major accidents involving hazardous substances, brings additional uncertainties, due to the lack of a certain assessment of the risks and record data gathered at European level in regards to specific risk sources, as well as tailings dams containing hazardous chemicals.
This document identifies major advantages which a standard risk identification and quantification methodology would have, in terms of dams' impact on the environment. The considerations taken into account are based on practical experiences gained through time. These are used to improve the legislation in order to avoid technical accidents caused by natural hazards (so called NATECH type events) such as the ones occurred in dams related to mining industry, like the Baia Mare accident occurred in year 2000. Moreover, several approaches are addressed for establishing a standard methodology for risk assessment, to be applied as a general methodology in mining, especially for dangerous sites such as impoundments containing hazardous chemicals.

Introduction
Hydraulic facilities, in particular tailing dams, are compared in terms of risk management to other industrial installations. The damages affecting the hydraulic facilities, caused by NATECH type events (technological hazards generated by natural hazards), or caused by human actions only (i.e: terrorism, sabotage), can be compared to the damages caused by major natural disasters.
The lessons learnt from the assessment of previous dam accidents, such as the one that occurred at the "Aurul" processing plant on the 30th January 2000 in Baia Mare (NW of Romania), are very important for improving the safety measures related to such hydraulic facilities. The major interest showed by the Authorities, as well as by the Public, towards ensuring constant operational safety conditions has resulted in in-depth examinations of the causes of major dam incidents, and the resulting damages, that have occurred worldwide. Such studies have been conducted in the context of risk management studies of the dams.
The implementation of the Acquis Communautaire at European level, especially at the level of the new Member States or Candidate States, which need to comply with the conditions imposed for integration in the EU structures, has deep implications at socio-economic levels. The implementation activity highly regards the safety issues related to the ongoing mining extractive industrial processes, especially in countries such as Spain, Turkey and Romania, where numerous gold mines are located.
The implementation activity requires numerous studies, guidelines, scientific publications, to be issued on dams' risk evaluation and management, in order to promote safe dam operation while using hazardous chemicals. The safe management of such dams must be ensured by a proper analysis of the risks.
The measurement of the risk components and of the final total risk related to dams and tailings must be based on a common ranking system, in order to address the safety standards and to gain a better parallel between their characteristics.
A main task in terms of risk management in the mining industry is the establishment of certain obligations for the dams' operators in what regards the safe operation and appropriate risk mitigation measures.
The control activity must be carried out at various frequencies, depending on the importance of the dam, its technical conditions, the risk degree and the impact on the environment.
A useful tool for the dams' operators should be the use of a standard methodology established on the basis of the measurement of each risk component, classified in accordance to their ranking of importance, and using a standard protocol for all involved parameters.

The risk assessment methodology for dams
According to the generally accepted definition, Risk equals the product of Probability and Vulnerability.
While the probability of generating a disaster is generally known, the assessment of the consequences is difficult and involves numerous unknown elements. Therefore, a great attention must be paid to the assessment of the vulnerability.

In this regard, there must be a comparison made, at national level, between the natural hazards which could inherently affect the dams (e.g. floods, earthquakes, land slides, frost-defrost conditions). Such an approach could lead to establishing priorities in terms of specific measures and needs, which the Local or Central Authorities of Technological risks management must present. It is also mentioned that the NATECH type hazards can be presented using GIS technique. This type of disaster has not been constantly assessed in Romania so far. Even the multiple risk term has been only recently implemented in Romania; this represents a new research line, and one of significant implications.

The hazard assessment methodology for dams

The hereby methodology is based on measuring the hazard components; the final value of the hazard related to dams and mining or individual wastes, are named dams and deposits. Its scope is to rank these structures in A, B, C and D classes, by using a defined system of criteria, notes and parameters.
The parameters used to assess the dams and deposits are the following:
1) The BA parameter, which is determined by the features of the dam or deposit (size, type, dischargers, importance), its site (the nature of the foundation land and seismic zone) and the condition of the water retention dam or, as the case may be, of the deposit;
2) the CB parameter, showing the condition of the operational dam and the existing deposits, depends on the supervision system, the maintenance works, the main data gathered in time (UCC) and the conditions of the water retention dam and of the scientific work annex;
3) the CA parameter which quantifies the consequences of the dam or deposit emergency, in consideration to the possible loss of human lives, the impact on the environment, on the socio-economic side, etc.
The dam related hazard is estimated using a parameter (RB) calculated by: RB = CA: (α x BA + β x CB), where CA, BA and CB parameters are as described above, and α and β coefficient have the following values:
α= 1 – for dams or deposits designed or verified in accordance to the current regulations;
α= 0.8 – for dams or deposits designed on the basis of old regulations;
α= 0.4 – for situations when the design data are unknown;
β = 1 – for dams or deposits under design or construction, or operational, of normal running along the entire time of operation;
β = 0.7 – for existing dams or deposits which encountered operation incidents or accidents, repaired through additional works.
The ranking of importance for tailings dams with mining and industrial wastes is determined in accordance to the value of the dam's risk parameter (RB), as follows:
RB > 0.8 – dam of exceptional importance (A);
0.8 > RB > 0.15 – dam of special importance (B);
0.15 > RB > 0.05 – dam of medium importance (C);
RB < 0.05 – dam of low importance (D).

The vulnerability assessment for the dam of the TMF

On the basis of the alert thresholds recently established (2005) for water pollution by ICPDR (The International Commission for the protection of Danube river) within the System of warning and prevention of accidents in the Danube Basin (Danube AEWS), Romania's position is to improve its assessment system in regards to the issues related to the safety of each facility operator, should this facility contain hazardous chemicals which could generate the pollution of the water. This means the improvement of the water's protection, but also involves the public's opinion in relation to the measures decided by the Competent Authorities of water management responsibilities.
The assessment of the alert thresholds for water pollution incidents, as part of the International System for warning and prevention of accidents in Danube Basin, can be done if the composition and the concentration of the hazardous chemicals stored onto a tailings dam are known, on the basis of the emission.
Tables 1 and 2 present the classification of the substances in accordance with the Risk categories for Aquatic Environment (Water Risk Classes - WRC) and/or the R-phrases related to risk which can be linked to certain alert thresholds. These alert thresholds (generated by an accident), as well as the ranking done in accordance to the Risk Parameters for Aquatic Environment (Water Risk Indexes -WRI) measure the vulnerability of surface water pollution in case of dam's accidents.
The water flows in Romania, part of the Danube Hydrographical Basin, can be split into two groups (please see Tables 1 and 2, of flow over or under 1000 m^3/s). The WRC categories are: WRC 3 = high risk for the aquatic environment; WRC 2 = medium risk for the aquatic environment; WRC 1 = low risk for the aquatic environment.

Table 1. The alert thresholds for rivers of flow up to 1000 m^3/s.

Substances		Alert thresholds	
WRC	Risk phrases	NOTIFICATION [kg] or [l]	WARNING [kg] or [l]
"0"	- 22	≥ 10000	≥ 100000
"1"	- 25, 52/53, 52 or 53	≥ 1000	≥ 10000
"2"	- 50, 51/53, 28 or 45		
	- (52/53, 52 or 53)	≥ 100	≥ 1000
	and (22 or 25)		
"3"	- 50/53		
	- (50, 51/53, 52/53, 52 or 53)	≥ 10	≥ 100
	and (45 or 28)		
	- 45 and 28		
Risk parameter for aquatic environment (WRI)		≤ 1	≥ 2

Table 2. The alert thresholds for rivers of flow over 1000 m^3/s.

Substances		Alert thresholds	
WRC	Risk phrases	NOTIFICATION [kg] or [l]	WARNING [kg] or [l]
"0"	- 22	≥ 100000	≥ 1000000
"1"	- 25, 52/53, 52 or 53	≥ 10000	≥ 100000
"2"	- 50, 51/53, 28 or 45		
	- (52/53, 52 or 53)	≥ 1000	≥ 10000
	and (22 or 25)		
"3"	- 50/53		
	- (50, 51/53, 52/53, 52 or 53)	≥ 100	≥ 1000
	and (45 or 28)		
	- 45 and 28		
Risk parameter for aquatic environment (WRI)		≤ 1	≥ 2

Explanation of the Risk phrases showed in Tables 1 and 2:

R22	Harmful if swallowed
R25	Toxic if swallowed
R28	Very toxic if swallowed
R45	May cause cancer
R50	Very toxic to aquatic organisms
R52	Harmful to aquatic organisms
R53	May cause long-term adverse effects in the aquatic environment
R50/53	Very toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment
R51/53	Toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment
R52/53	Harmful to aquatic organisms, may cause long-term adverse effects in the aquatic environment

The WRC values (for German language: WGK values) are available in the web site: http://www.umweltbundesamt.de/wgs/wgs-index.htm (Katalog wassergefahrdender Stoffe, LTwS Nr.12, Umweltbundesamt 1991).
The risk parameters for aquatic environment are used to establish a hierarchy of water pollution events.
Table 2 presents clues regarding the vulnerability assessment in Romania, mainly for the major water flows (i.e. Somes River)
The entire list of "R" values is contained in the 67/548/EEC Directive for the ranking, packaging and labelling of hazardous chemicals.
In WRI assessment, the hazardous chemicals are named using equivalent terms, established on the basis of WRC 3 (Table 3).

Table 3. The expression of hazardous chemicals when used for Aquatic Environment Risk Categories.

The quantity of the chemical expressed in kg	The value of WRC	The quantity of the equivalent in WRC system
M	0	M x 10^{-3}
M	1	M x 10^{-2}
M	2	M x 10^{-1}
M	3	M

The Water Risk Index (WRI) value is equal to the 10 based logarithmic value of the summarised equivalent values of the WRC, as it follows: WRI = log (ΣWRC).
The values of the Water Risk Index (WRI), can be therefore assimilated with the vulnerability at the accidental pollution of the tailing dams, being a very important factor to be taken into consideration when estimating the overall risk of this kind of establishment, after the hazards assessment is done as previously indicated.

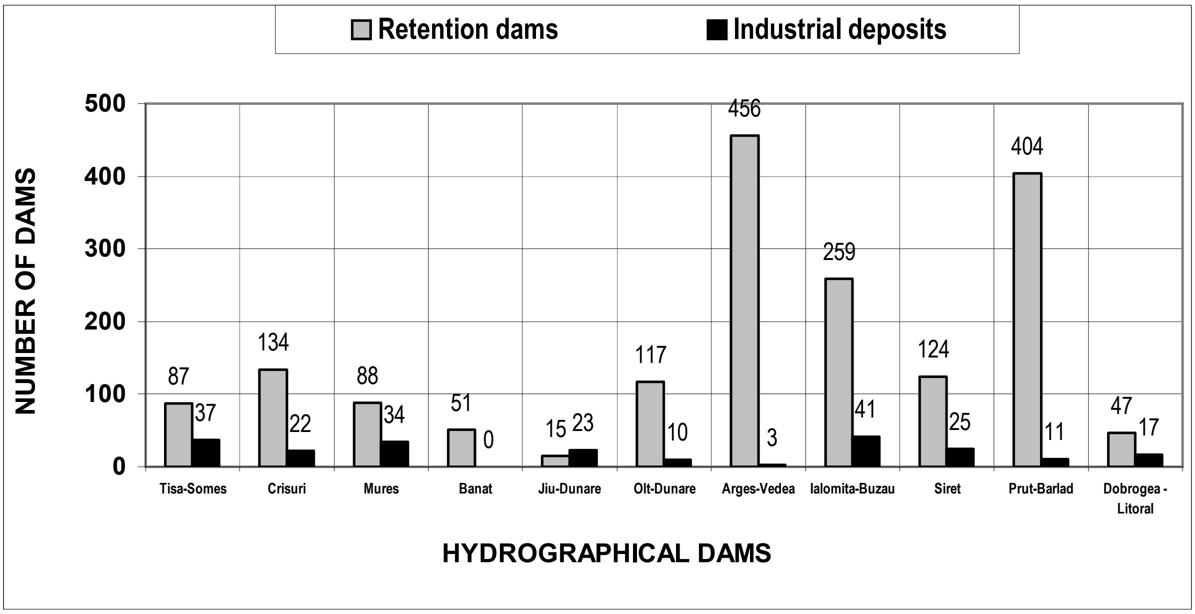

Figure 1. Inventory of the tailing dams in Romania by hydrographical basins.

Findings

The risk related to the surface water of the dams can be established using the Formula below:

$$\text{Risk} = \text{Probability} \times \text{Vulnerability} = RB \times WRI = [CA/(\alpha \times BA + \beta \times CB)] \times \log(\Sigma WRC)$$

The new risk assessment methodology for tailing dams in Romania, once applied, will bring the following benefits:
1) it will allow people in charge with the risk management to conduct a better assessment of the risk related to technical aspects of the tailing dams (Fig. 1), different to conventional installations used to store hazardous chemicals, highly vulnerable for surface water and environment;
2) greater possibility to assess the damages and the socio-economic impact in case of failure;
3) issuance of operation procedures to ensure safer operation of the tailing dams in the chemical and mining industry;
4) identification of the hazard sources and accident scenarios related to NATECH type events which the dams can encounter.

References

ICPDR (International Convention for the Protection of the Danube River) (2005). Alert thresholds for extraordinary water pollution in the framework of the International Danube Accident Emergency Warning System.

Mara S., Tanasescu M., Vlad S.N., Ozunu A. (2006). Lessons learnt from recent failures of tailing dams and their integration in the national legislation of Romania, after the NATECH type accident from Baia Mare. Geophysical Research Abstracts, Vol. 8, European Geosciences Union 2006.

Mara S., Tanasescu M., Vlad S.N., Ozunu A. (2006). Recommendations for legislation improvement to avoid technical accidents due to natural hazards (NATECH events) at the tailing dams from the mining extractive industry (drawn from Lessons learnt depicted from recent tailing dam failures, including “Baia Mare” accident). International Disaster Reduction Conference, Davos Switzerland August 27th – September 1st, 2006.

Official Gazette of Romania (2002). Order for the approval of the procedure and competencies of control for tailing dams’ safe operation - NTLH 034, February 2002, the Official Gazette of Romania.

Official Gazette of Romania (2002). The Regulations established for organizing and certifying the experts to assess the safety of dams’ operation NTLH 014, NTLH 015, February 2002, the Official Gazette of Romania.

Official Gazette of Romania (2001). The Emergency Ordinance of the Government no. 244/2000 for the safety of dams, approved and amended by Law no. 466/2001.

Official Gazette of Romania (2002). The methodology used to establish the categories of importance for dams – NTLH 021, approved by the Order of the Minister of Environment and Water Management and of the Minister of Public Works, Transport and Housing no. 115/288/2002.

Official Gazette of Romania (2002). The Methodology regarding the evaluation of secure operation of dams and accumulation lakes - NTLH 022, February 2002.

Official Gazette of Romania (2002). The Methodology for the assessment of the safe operation of the tailings dams where industrial waste is deposited - NTLH 023, February 2002).