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- CONTRIBUTION REGARDING THE RISK EVALUATION FOR THE NATURAL AND TECHNOLOGICAL HAZARDS IN THE MINERAL RESOURCES INDUSTRY

- PhD THESIS SUMMARY -

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Contents

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Note: When drafting the summary they were kept the same notation for chapters, tables, formulas and figures used in the text of the thesis

1. Introduction - importance of the thesis

Detailed study of geological phenomena related to the interaction geosphere - hydrosphere and analyzis of the processes involved, in the context of an increased globalization 's growing impact over the exploitation of mineral resources, an activity with the most diverse and profound impact on environmental factors (on lithosphere, by polluting underground and surface land till to the atmosphere, represented by massive releases of greenhouse gases due to the exploitation of mineral resources, the effect of worsening the hydro-meteorological phenomena on an anthropic environment, regarding the negative interaction with environmental factors), requires detailed analysis of the risks involved together with the identification of geological engineering solutions and hydrogeological applications for mitigating their effects.

Following recent technical accidents in Europe, of which the latest is the dam failure at the Ajka (Hungary) from 04.10.2010, we consider it necessary to improve safety requirements in industrial risk management activity and public safety of the establishments involving mining and processing of mineral resources, focusing on technical risks. Therefore we need to adopt improved legislation in safety issues in the EU and candidate countries (including countries with a tradition in the EU, such as Spain or Romania and Turkey as a candidate country, where mining activities are developing because of existing large deposits gold) (DG-JRC, 2004). It is necessary to emphasize that in Europe, development of new technologies for work mining (particularly for precious metals operation) lead to the development of new extraction and processing operations implemented, for the first time in these countries.

By analyzing existing legislation technical safety in mining, it showed that the risk associated of tailing ponds is difficult to assess, not only for owners of ponds (which operates) and local authorities, population and economic entities in areas exposed (Martin et al, 2002). Knowing that an objective of the Risk analysis is primarily to improve the operational safety of a technical objective, we concluded that measures of protection are needed to be accomplished in order to minimize the effect of possible accidents in mining, are very expensive. Cost detailed analysis and evaluation of safety in the operation of a mining pond is determined mainly through the analysis to avoid an ecological catastrophe (DME, 1998), which included environmental and assessment prior to commencement of mining activities themselves.

The paper proposes, through a detailed analysis, to improve safety conditions for this type of dams, for a proper management of mining tailings dams and avoid accidents such as occurred at the Aurul tailings at Baia Mare in 2000 (UNEP, 2001).

In particular hydraulic structures and dams, including tailing ponds are comparable to other industrial facilities in terms of risk management. The damage in case of an accident at the dam, due to an event, exclusively NATECH or human causes (eg. sabotage, terrorist acts, etc.) can be compared with those of natural disasters (without causing direct technical accidents), with huge economic losses (economic damage due to impact properties flooded). Fulfilment of conditions for safe operation through an appropriate risk management tailings dam is supported by the significant interest and public authorities, given that a large number of casualties and extensive damage occurred at international level, due to accidents at dams (Bruce et al., 1997).

Therefore we believe that providing a safe operation must include the following requirements (BRGM, 2001):

- Monitoring operating programs;
- A system of protection and safety;
- The application of security measures to ensure appropriate management in the dam area or near it;
- Installation of control and measurement equipment for monitoring the behavior of the dam in time;
- The existence of authorization procedures for safe operation of the tailings;
- Information System - alarming the population and socio-economic units located downstream in case of accident;
- Implementation procedure interruption or abandonment reuse of tailings.

Due to new requirements related to implementation of the new Seveso II Directive with amendments (OJ-EC, 2003), we believe that competent authorities in Romania must adapt to the new requirements of implementing approaches to operational safety of tailing ponds ***(fig. 36).*** It is noted that Directive 96/82 / EC was transposed into Romanian legislation by Government Decision 95/2003, which translates it literally almost the whole content of the directive (subsequently repealed and replaced by Government Decision no. 804 of 25 July 2007 on the control of major accident hazards involving dangerous substances).

Quantification of the risk associated with mining tailings and industrial landfills requires the use of a unitary system of categorization for better correlation between the characteristics of the various sites and the associated potential hazards. Management of these risks requires owners of dams and obligations of operators to be defined, in ordered to be operated in a safe and appropriate measures taken to reduce the risk of accident (Mara et al., 2007). For timely identification of potential accidents are needed checks on time, different in typology, according to the potential risk and environmental impact, in particular on surface water. It should be remained, in this respect, the technical accident at Baia Mare 30 January 2000 when a tailings dam was damaged plant to recover gold from tailings *gold* due to excessive liquid precipitation fallen over a thick layer of snow (EEB, 2000), which led to a major overflow discharge. This accident, produced during the night of 30/31 January 2000 occurred as a result of abundant rainfall over a thick snow layer, about 35.7 l/ sq.m. during 24 hours, combined with sudden increase of temperature, unusual for this period of the year, leading to melting of the snow layer of about 43 cm thick, existing on the surface of the pond. Therefore was reached and exceed the maximum water level in the tailing pond and subsequently determined the release the industrial water with an increased cyanide content.
Approximately 100,000 m³ of a high cyanide and heavy metal containing wastewater were discharged into the receiving creeks, and from there onwards into the river network of the Danube Basin (Somes/Szamos; Tisza and the Danube) until reached Danube Delta.
In the same region, another tailing dam broke in Baia Borsa on 10 March 2000, due to a severe rainfall, spilling 40,000 tones of heavy metals containing sediments.
These two serious accidents with a transboundary impact initiated a rapid response within both the ICPDR and the EU.
The Romanian PIAC announced in due time the population and the transboundary countries, using the DBAM-model for pollution propagation, in order to take the necessary measures for preventing any contamination, being noticed that no any affected persons were recorded.
Also the data transmitted in due time by Romanian PIAC, were forwarded by the ICPDR Secretariat from Vienna directly to Mrs. Margot Wallström, the European Commissioner on Environment Protection. These allowed the spreading to media, of the accurate information about the pollution evolution and the measures taken in due time by the Romanian authorities in order to diminish and to avoid any adverse effects of the accidents against the water users and the environment (EC, COM 2000). For improving the detection of accidental pollution, it requires that the monitoring system of environmental factors must be modernized, notably by adding automatic stations for continuous surveillance of water quality parameters. They must be located mainly downstream and upstream sources of pollution of transboundary watercourses to provide timely information to the downstream countries in accordance with local or international agreements in the field of water protection.

The compliance activity with environmental requirements in Europe, for the mining sector, is a difficult and very costly process (Symonds Group Ltd, 2001), which requires significant investments towards environmental requirements, especially in the field of water quality, knowing that water treatment of the mines is very expensive, particularly through provision of wastewater treatment plants. Therefore a global approach, is needed, not only in sectors of environmental issues in the mining sector, but also for different categories of environmental factors affected (air, water, soil, subsoil, groundwater, etc.). Clarifications over the ownership regime of the mining companies, is necessary for providing financial guarantees to cover compensation for reducing adverse effects on the environment, a key element in this process. A transboundary pollution usually lead to increased penalties, for compensation of the downstream country potentially to be affected, to be payable for the effects on river water (pollution) and disturbing of the economic activity in the area (additional costs for closing catchment area in order to protect consumers, etc.). Water Framework Directive 2000/60/EC, provides legal liability, in order to pay compensation in the event of accidental water pollution.

In our analyze we identified that the problems due to the mining industry impact, it covers the following issues, encountered also in Romania, in the frame of the environment rehabilitation:

- The mining activity has a strong impact on the environment;
- Emission of pollutants in air (NOx ;CO; SiO2 ;SO2);
- Emission of pollutants on surface and ground waters (heavy metals, sulphates, chlorides, carbonates and others) (Norton, 1992);
- Soil pollution, hydrological and landscape changes in the area;
- Occupation of a large area of terrain for the exploitation activity, industrial facility, waste deposits and tailing dam;
- Disturbing of natural habitats; Affects cultural and historical sites;
- Damage of cultural and historical sites;
- Long term effects over the environment during activity and after the closure of the mining activity;
- • The environmental problems have been accumulated in time (The mining industry in Romania has been practiced for more than 2000 years (Mara et. al, 2011c), and the effects of pollution are felt today like reddish waters, due to the phenomenon of acid generating as a result of Roman galleries, which allowed oxygen to come into contact with rock ores rich in sulphur minerals)) and the first written document dates from the year 132 a.d., on wax tablets, and it was found in Rosia Montana (Alburnus Major), Alba county)

In Romania, the key components of approaches regarding the mining sector are (Mara et al., 2009):

- the management of the wastes from the extractive industry;
- the decontamination issue of the air, waters, soil and subsoil, as a result of the mining activities.
- Ministry of Environment is engaged to speed up of the assurance of safety mining activities, in order to respect the European and worldwide standards for the environmental protection. All the activities concerning mining are carried out by allocation of financial recourses, also by imposing the legislation for the mining activities which are going to be open or still running.

Ministry of Environment is also involved to accelerate this safe environmental activity by assuring a compensation fund for the mining activities to be opened or are under preparation.

It has to be specified that Waters and environmental legislation in Romania regarding the mining activity includes:

- Waters Law nr.107/1996, Environmental Protection Law nr.137/1995 including modifications and additions, and subsequent regulations;
- Safety Dams Law nr. 466/2001 and subsequent regulations;
- Prevention and Integration Control of Pollution Law nr.645/2002 and subsequent regulations;
- Seveso Governmental Decision nr.95/2003 including amendments;
- Also was elaborated the Governmental Decision for recovering of the affected mining perimeters, which are obligating the mining operator, public or private, to support the recovering measures of the environment. Together with the above mentioned Governmental Decision, was elaborated the Strategy for Management of the Contaminated Sites and the

methodological guidelines for recovering the geological environment of the contaminated sites.

- Almost 400 millions euro has been invested in recent years for closing down and cleaning up of the mining areas. Complementary, by the Sectorial Operational Program – Environment, are already established the finance through European funds, during 2007 – 2013, of 5 projects on contaminated mining sites, totaling 171 millions Euro, and following for the next programmatic period, 2014-2020, to extend the measures to prevent accidents involving mining waste and other chemical ponds.

2. Valorification of the deposits of useful minerals in Romania and environmental impact

2.1. Mineral resources - generalities

Our analysis of the economic growth indicators versus sustainable use of resources available, indicated that use of the earth's limited reserves and energy resources can`t keep up with the trend of the economic development *(Vlad, 2005).* The mineral resources tend to be used at a rate that exceeds their conversion process of recycling of wastes, and in order to support a sustainable economy, it is necessary to take into account the potential needs of future generations (European Parliament, 2004).

2.1.1. Classification of mineral resources

From the economic point of view, the resources represent any type of available means to be valorified in a particular circumstance. For the environment, it`s about natural resources, but in the particular case of geological factors, the resources taken into account covers all useful substances from the surface of the crust. From the point of view of geological features, mineral resources are defined as natural accumulations likely to be exploited, with mineral products (metal, industrial mineral, useful materials used in construction such as sand, gravel, etc.), minerals and ornamental rocks, solid mineral fuels (peat, coal) and liquid (oil) or gaseous (natural gas), groundwater and mineral waters.

2.1.1.1. Global trends influencing the industry of Mineral Resources (IMR):

Our analysis at international level, of the assessment of needs for useful minerals at global level, and the evolution of the mineral resources and their developments, highlighted the following aspects:

- The international market of mineral resources exploited by mining and subsequent processing, recorded continuous growth as a result of the requirement of raw materials for processing and processing industries. Thus in the last hundred years have seen an increased activity of extraction of mineral aggregates for the construction sector with a multiplication factor of 34 times, while useful ore extraction activity increased 27 industrial times. This will expand the impact of mining activities on the environment, due to the increased requirement of minerals necessary, especially for emerging economies, but also in advanced countries, usually with lower production;
- The recent failures of the of tailings ponds have shown that they can still lead to environmental catastrophes and credibility of these types of investments can be lowered, and the environmental costs is generally incalculable and could not been integrally covered the environmental damages (for example the pollution of the Quesnel Lake with toxic heavy metals, such as arsenic and selenium, following the failure of a pond from British Columbia, Canada, in August 2014. The failure is due not complying the elementary conditions for dam building, as it has been highlighted in the Report on the specific event, issued in January 2015, for making the tailing dam without preliminary geotechnical exploration in detail, which revealed the presence at the tailings base of a glacial moraine layer, with unassessed draining

characteristics and different resistance of the interlayer surfaces, reducing the resistance. Also were not recorded any additional inspections during construction, in 2012, for example), and a big question mark were regarding the piezometers, wrongly positioned probably without to record any pressure anomaly before the accident.

- It is estimated that about a third of the global mining operations are located in areas with water shortages and the remaining two-thirds in areas with significant water deficit (lower annual reserve of 1,000 cubic meters/year). Such water resources have become a strategic issue internationally for mining, not only because of increased demand for these uses, including the local population who feel uncertainty regarding the quality of this strategic resource, in terms of increased impact of the invasive industrial activities.

2.1.2. Criteria for exploiting mineral resources on global sustainable development

Because in developing countries are located approximately half of total global reserves of metals deposits, predominantly represented by copper, due to the growth trends of the past 15 years, it is necessary for extraction to ensure the conditions for an operating activity decoupled from economic growth, in order to diversify support activities related to the extraction, processing and capitalizing, in order to avoid a significant economic impact of their depletion in the near future;

2.1.3. Main factors for development of primary mineral resources

Our analysis focused on the effectivnes of the exploitation of mineral resources, from the analysis of global industrial production by type of usable ore; this analysis revealed that in countries where mining ores have a high importance, for example for diamond reserves, an usual trend is that their governments, because of economic advantages, to support exploration companies to diversify the country's exploitable resources, for example by finding possible associated deposits of platinum, gold, copper or oil, highly rated international markets.

- It is of prime importance to implement advanced technologies of exploitation of recently unapproached deposits due to difficult operating conditions, such as those at high depths with difficult geological conditions. Thus, because of the technological advances and the emergence of new technologies for alloys, some minerals are the most recalled:

- Lithium, for catalytic applications, with growing demand, high-range batteries, widely used for mobile phones and aircraft.

- Exploiting new sources of minerals without the need for major exploration costs are the seabed resources:

- Mn nodules;
- precious and semiprecious stones from river silt deposits;
- exploitable diamond (ie located in the Atlantic Ocean, in the golf area of Alexander Bay, downstream of the Orange River in South Africa) as the alluvial funs, settled in the last 20 million years by fluvial transport, which can be easily exploited by suction, by independent divers using autonomous devices with advanced equipment and high capacity suction tool of stones absorption and subsequent sorting, also GPS guided ships without coming into contact by human;
- rare elements;
- hydrocarbons resources because of the he decreases of the Arctic sea ice due to climate change due to anthropogenic pollution with greenhouse gases in the last decades, caused by burning fossil fuels (Mara & Vlad, 2013), in industrial activity, with a significant peak growth, increasingly leading on international market in recent years, with the world record held by China, for the exploitation of coal resources.

2.1.4. Metalliferous mineral resources classification

By analyzing the available data at EU level, the JRC database, was concluded that the geological reserves are the amounts of useful minerals, characterized in terms of quality, technology and service that can currently be valued in perspective withouht to be exhausted in the near future.

2.1.5. Policy for the enhancement of mineral resources

The term of mineral policy is a set of measures which it envisages the measures at the level of legislative, legal, institutional, technical, scientific, etc., activities of the countries governments, in order to ensure and promote activities for the development of mineral resources. Its objective is to ensure an efficient exploitation of subsoil resources as an integral part of macroeconomic policy of the concerned country

2.1.6. Recent initiatives to rehabilitate IMR at international level

From our analysis at level of both European and International resources, from the European Commission, JRC, we deduced that the restructuring of activities IMR is currently coordinated internationally, through various initiatives of developed industrial countries, the most important being the Global Mining Initiative (GMI). Thus GMI focuses mainly on the systematic evaluation of mineral resources on a global scale, promoting sustainable development, with consequences in the future (Resourcing the future) *(Vlad, 2005).*

GMI foreseen the following activities (University of Michigan, 2013):

- recycling as part of MRI;
- use of materials and industrial processes environmentally friendly, to reduce the greenhouse effect and decrease the accumulation of tailings / waste (Hellier, 1998);
- implementation of sustainable development at the level of the mine, for example post-use for recreational purposes of the depleted mines (eg. Salina Turda, Cluj County, recently designated the most beautiful landscaped saline in the world;
- obtaining basic information on global distribution of the potential resources (yet undiscovered) and the political /environmental influencing their operation in order to obtain metal content models that facilitate the management of MRI.

GMI`s Global Strategy is keeping an appropriate balance at the level of resource-environment-society, represented by the following principles:

- maintaining the balance between demand and supply of mineral resources;
- maintain a balance between economic pressure and the need to remedy the historical environmental pollution.

2.1.7. The impact on enhancing the activity of mineral resources on the environment – generalities

Following our analysis of the activities of the European Commission – JRC, of the internationally exploition mines, that uses hazardous substances in the production cycle, we concluded that the impact of activities related to mining is studied in the context of the following major issues:

- assessment of natural hazards (floods, landslides, earthquakes, tsunamis etc.), in order to limit the negative effects on people and the environment in the event of disasters that may involve technological accidents;
- spatial planning, the selection of favorable areas for different categories of utilities, landscapes preservation, studies of environmental impact, and analyzes of environmental factors;
- the assessment activity of the soil's mineral resources (chemicals, minerals, soils, rocks, water) to implement the concept of sustainable development. Along with the use of resources is envisaged the safe storage of the waste material (wastes), to eliminate environmental impact (Gowan, 2000).

In some areas with metallic ores, sterile tailings dumps resulted of minerals exploitation, could contains high concentrations of useful minerals, so that may be the subject of a new reconversion (Sobek et. al., 1990) in parallel with the development of processing technologies for metallic ores with low concentrations of useful elements, which are leading to increased degree of recycling of waste (***Fig. nr. 4***.).

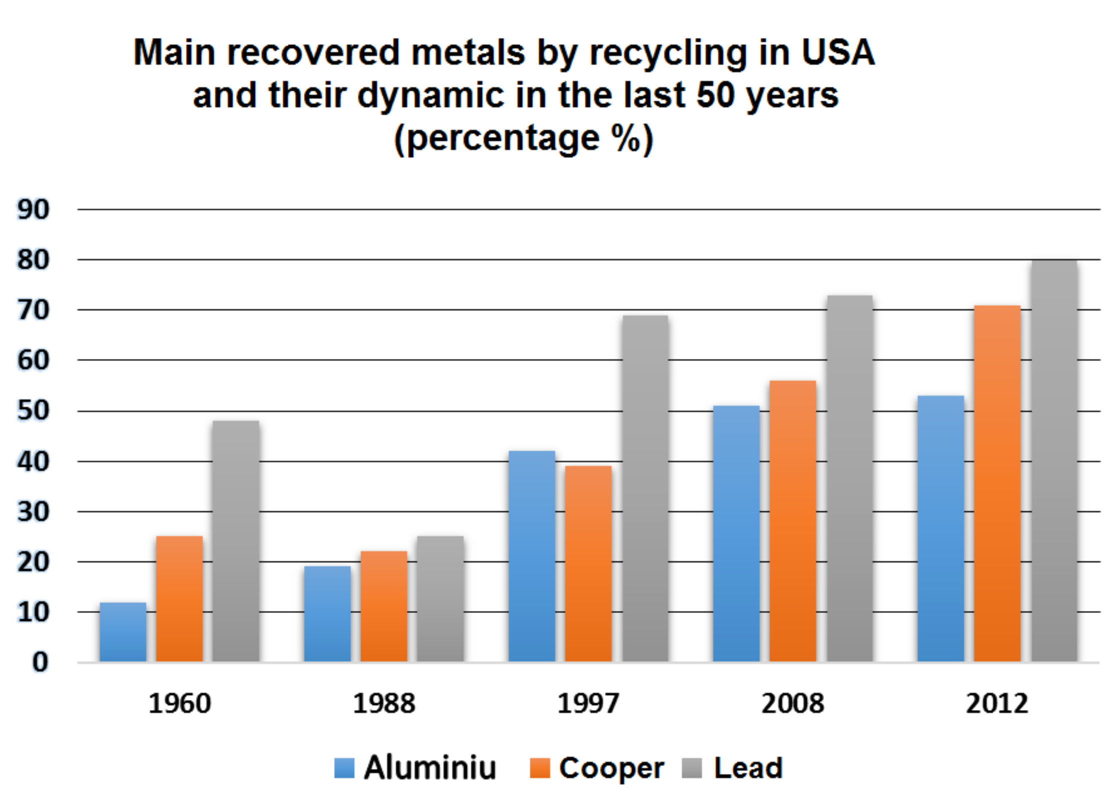


Fig.nr. 4. *Developments in US of recycling metals from waste (adapted from Vlad, 2005 USGS, 2013)*

Based on lessons learned from historical pollution with heavy metals and effects on the human body (from lead poisoning, caused by the use of lead containers to store wine in the medieval period to the disease "Itai-Itai" (the suffering caused by the sound of breaking internal bones) as a result of poisoning with Cd and "Minami desease" because of poisoning due to mercury (named after the bay where evacuated after being transferred mercury residues in aquatic ecosystems and in human tissue ingestion), from 70`s due to the economic boom and unprecedented industrial development of Japan), we consider extremely important that some heavy metals are very toxic, for example Cd (who once in the human body produces bone fragility) or Hg (nerve edema), subsequently causing death after serious suffering. Therefore we concluded that it is necessary to equip all sources of pollution extraction, or processed metal ores, with treatment stations (Kleinmann, 1990) even if there is no downstream users, because sediments are also polluted, which can be remobilized subsequently using alluvial sediments with high load of heavy metals, in agriculture or other economic purposes.

2.2. Analysis of the general metallogenic characteristics of Romania

2.2.1. The activity of exploitiong mineral resources in Romania

We considered in our analysis to point out that Romania has a complex geological structure and mineral deposits are related to the tectonic evolution of large structural units, given that around two thirds of the territory belongs to Alpine orogenic zone, affected by the Neogene volcanism, responsible for many metal deposits (fig. a).

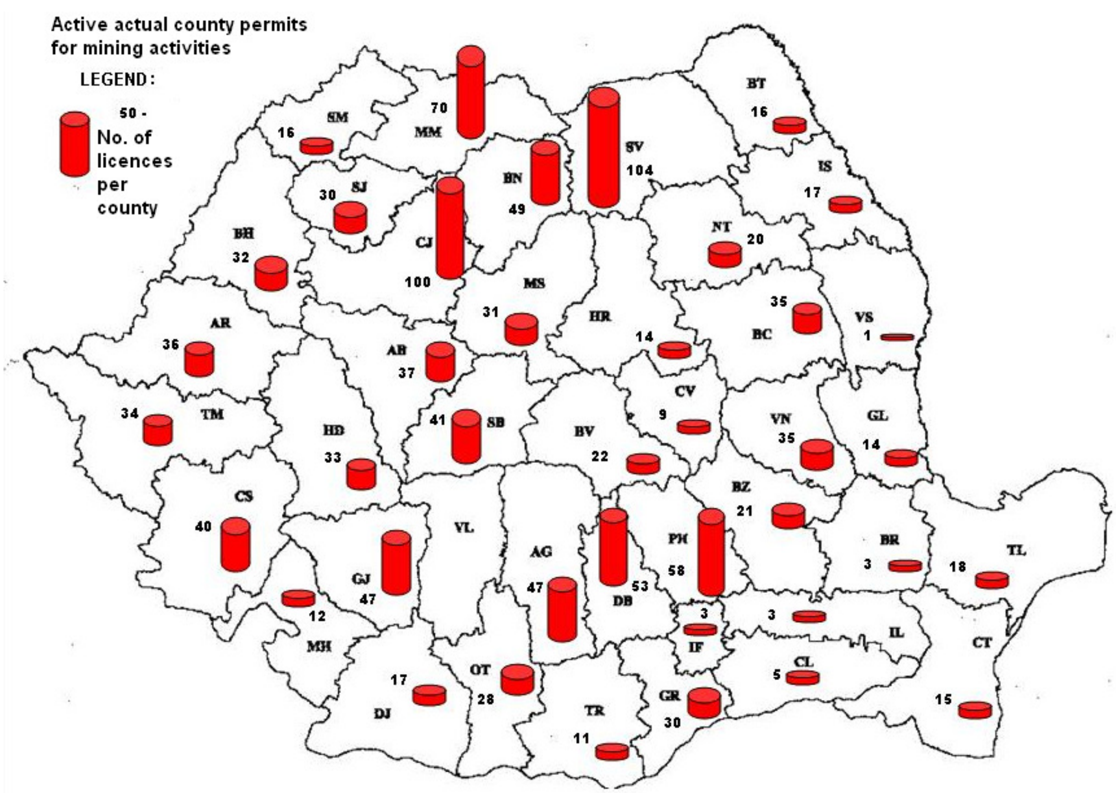


Fig.a Present status of the active mining exploitations in Romania by counties

2.2.2.1. The impact of exploiting mineral resources in Romania

Generally, in Romania, the exploitation activities of mineral resources comprise the following phases:

- prospecting;
- exploration;
- exploitation;
- concentration.

These activities lead to possible environmental pollution factors, mainly due to:

- mine waters (Fernández-Rubio & Carvalho, 1993);
- waste water - polluted water resulting from ore processing processes (Bosman et al., 1990);
- structural stability of the areas where underground and surface activities are present (Jambrik, 1994);
- noise pollution or light during operation (career explosions etc.);
- the visual impact of the landscape degradation.

Pollution resulted can have a direct or indirect, immediate or a long-term effect (Chileshe & Kulkarni, 1992).

Due negative landforms created due to the operating phase, can be produced changes in groundwater circulation (Kipko et. al, 1993), soil geochemical changes, erosions, landslides (Yu, 1994).

The main feature of the ferrous deposits in Romania, the sulfides mineralization, along with pyrite and marcasite in the aerobic conditions and the presence of bacteria, forms sulfuric acid, which is generated from the oxidation of sulphides (Armstrong, 1994). This process leads to the presence of mine water with a pH between 1,5-3 acid, which mobilize from wastes of the heavy metals such as copper, zinc, cadmium, arsenic and lead (Gajowiec & Witkowski, 1993), leading the pollution of soil and vegetation (Carvalho et al, 1990). Also heavy metals entering the food chain significantly affect humans, by ingestion of toxic foods and by progressive accumulation effect (Xavier, 1990).

2.2.3. Rehabilitation of areas affected by pollution from mineral resources exploitation activities and post-maintenance methods:

Selecting the method for designing the tailings dams and rock or minig waste management depends mainly on the evaluation of three factors, as follows:

- the cost of setting up a landfill mining;
- environmental performance of the method of implementation of the waste dumps;
- failure risk of the dam from the waste pond or platform, from case to case.

2.2.4. National inventory of tailings ponds

Following our analysis showed that in Romania there are a number of over 200 industrial deposits held by various mining companies and traders.

Distribution of dams of the industrial landfills for each water basin directorates territory (***Table no. 4***) is presented as follows:

Tabel.4. Hydrographical basins distribution of the tailing dams

Hydrographical Basin Directorate	***Industrial tailing ponds***	***Hydrographical Basin Directorate***	***Industrial tailing ponds***
Someş – Tisa	27	Arges - Vedea	4
Crisuri	25	Buzău – Ialomiţa	18
Mureş	35	Siret	22
Banat	8	Prut	14
Jiu	25	Dobrogea - Litoral	17
Olt	10	**TOTAL**	**205**

2.2.4.1. Problems of tailing ponds in Romania

Thus, in our study we identified that many **industrial tailing ponds** have a series of deficiencies:

- clogging the dam draining ditch;
- the emergency ponds are inoperative where they are present;
- Erosions on the slopes produced by precipitation (runoff);
- Seepage from the dump (Saharan, et al. 1995).

Thus, much of owners of the industrial deposits and reservoirs, have not so far complied the actual legislation in force on the safety of dams, in order to have prepared documentation of the safety assessment (90% of works) and without operating instructions or systematic organization of monitoring the behavior in time.

There are many ponds whose activity has ceased, were passed in conservation but no expertise documentation was elaborated, stating this stage of their existence.

2.2.4.2. Tailing ponds in operation after EU accession

In our study we identified a large number of ponds still in operation at the time of accesion, but their activity has decreased gradually being passed in conservation (excepting Valea Şesei Tailing Dam with further prospects in the future because the exploitation of copper in the area will continue).

3. Socio-economic implications of NATECH disasters type (technological accidents caused by natural hazards) on mining tailing ponds and lessons learned from historical events

Following the lessons learnt from recent tailing dam failures due to NATECH events (such as Baia Mare (2000), resulting in cyanide contamination of the Somes, Tisza and Danube River downwards to Danube Delta, before entering in the Black Sea, and Ajka (Hungary), from 04.10.2010, leading to 10 human fatalities, 100 injured persons, 2000 destroied houses and 1000 ha of contaminated arable land, a common methodology for evaluation and mapping of the risk caused by the natural and technological hazards posed by tailing dams, to be implemented in order to elaborate vulnerability and risk maps, using a dedicated GIS for storage and information dissemination to decision makers at various levels, will be very useful both for extractive industry and nearby potentially affected local population.

In this regard, a comparison, at national level, between the natural hazards which could inherently affect the population and the surrounding environment (e.g. floods, earthquakes, land slides, frost-defrost conditions) is highly recommended . Such an approach could lead to establishing priorities in terms of specific measures and needs, which the authorities involved in the natural or technological risks management must address. An improved management of the areas affected by natural and man-made disasters, will allow an accurate analyze for taking decisions, assuring an improved activity of prevention, mitigation and restoration of the areas affected by disasters, increasing the safety of the public and the confidence in the safety measures taken by the public administration.

The newly implemented methodology proposed by this paper, for estimation of the vulnerability and risk that threatened the different forms of property, will better establish the responsibilities and the rules of land use development and planning of the territory.

While the probability of the disaster is generally known (for example the return period of 100 year for a flood event), the potential consequences of a disaster can be difficult to quantify and this involves a lot of unknown factors. Therefore, special attention has to be given to assessing NATECH vulnerability (Krausmann, et. al. 2010).

It has to be specified that generally, any damage assessment is made in order to ensure the compensation to the affected persons. The insurance companies have so far a weak involvement in the activities for preventing and reducing the effects produced by the natural and technological hazards in Romania. The insurance companies are unwilling to insure goods and properties located in natural disaster-prone areas (Mara & Vlad, 2009b). The great contribution of the financial resources for minimising the damages caused by the natural disasters (Table 7) are the funds allocated from the State budget and external credits in this purpose (Mara & Vlad, 2009a).

Tab. nr. 7. Disaster profile of Romania

Disaster	Floods-drought	Land-slides	Storms	Earth-quakes	Forest Fires	Contami-nated Lands	Industrial Install-ations	Transport of Dangerous Goods
Severity								

Legend:
high risk
medium risk

The natural disaster more frequently in Romania which produced the greater human losses and material damages, are as it follows: floods, earthquakes (Mara & Vlad, 2013), landslides and storms. History of the most catastrophic disaster of Romania, in the recent history are presented in the table no. 8.

Tab 8: The most important damages ever recorded due to natural disasters in Romania

Year/data	Type of disaster- feature	Human life	Injured	Homeless	Affected	Damages (mil USD)
4 March 1977	Earthquake – 7.5 Richter scale magnitude	1641	11300	175000	386300	2000
May 1970	Flood	215			238755	1000
July 1975	Flood	60			1000000	750
11-12 July1999	Landslide (mudflow)	13				
April-September2005	Flood	78			30800	1958
April-May 2006	Danube river Flood	1		16350		225
July 2008	Floods due a retrograde cyclone	5			27000	830
June-July 2010	Floods due a retrograde cyclone	22		12457		867

Generally, the damages produced by the natural disaster can't be fully covered by the state funds, so a better involvement of the insurance companies (Mara & Vlad, 2008b), which will be able to estimate their insurances primes depending the estimated risk for every property and facility, using the maps elaborated with the newly implemented multi-disaster risk evaluation methodology and NATECH failure index of the tailing dams, proposed by this paper, will solve the problem of indemnity for affected people by technological disasters involving waste mining activities (Sammarco, 1999).

3.1. Requirements for NATECH risk assessment at national level

The advantages of using GIS methodology for developing county-wide vulnerability and risk maps for various hazards (natural disasters such as: floods, severe storms, earthquakes, landslides, forest fires and technological disasters such as: industrial accidents, transportation of dangerous goods, contaminated lands, including those by mining activity) request a pilot project of a county with a currently implemented GIS system in its public administration. A follow up project is to be implemented, for multi-disaster risk maps of the entire country (Fig 8), by involving mainly National Geological Services, SGN, respectively the Geological Instititute, Geological Museum, etc (Mara et al, 2007d). These newly implemented risk maps assist the stakeholders and insurance companies to evaluate the total disaster insurance needs from a single source of information.

In this regard, a comparison, at national level, between the natural hazards which could inherently affect the population and the surrounding environment (e.g. floods, earthquakes, land slides, frost-defrost conditions) is highly recommended. Such an approach could lead to establishing priorities in terms of specific measures and needs, which the authorities involved in the natural or technological risks management must address. An improved management of the areas affected by natural and man-made disasters, will allow an accurate analyze for taking decisions, assuring an improved activity of prevention, mitigation and restoration of the areas affected by disasters, increasing the safety of the public and the confidence in the safety measures taken by the public administration.

Developing a common methodology for evaluation and mapping the risk posed by the natural and technological hazards, to be implemented under a pilot project at the county level (fig. 8) in order to elaborate vulnerability and risk maps, using a dedicated GIS for storage and information dissemination to decision makers at various levels.

The newly implemented methodology for estimation of the vulnerability and risk that threatened the different forms of property, will better establish the responsibilities and the rules of land use development and planning of the territory.

The main advantages of this project are the following:

- The implemented methodology for estimation of the vulnerability and risk that threatened the different forms of property will better establish the responsibilities of the administrative bodies and will help the future decisions related to land use and planning of the territory.

- The newly implemented system of risk mapping provides the stakeholders and the insurance companies a unique source of information to assist their decisions: the GIS risk map from the county or local public administration.

- The tight connection between Romanian experts in different hazards, natural and technological, will led to innovative aspects in the field of disaster mitigation and protection.

-The stringent problem of indemnifying the people or institutions affected by natural and anthropogenic disasters will be solved through the implication of the insurance companies (Mara & Vlad, 2008b).

- Delimitation of the areas prone to natural risks, using GIS maps, also for prevention and attenuation of the effects, which are produced by the destructive natural phenomenon and to the risk posed by the tehnological hazards, will assure the population safety.

It is also mentioned that the NATECH (technological disasters due to natural hazards) 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, as a result of the recent integration in the EU structures, and transposition of the legislation in the field of the dangerous instalations, which took into consideration the possibility of the impact on diferent categories, including population, installation and environment, taking into account the natural hazards present in the concerned area (according to Seveso III Directive, compulsory since 2015, in EU including Romania)..

3.1.1. Organization of the NATECH risk management type at national and local level

In the frame of the global activity of preparedness against the disasters, represented also about the events caused by the mining activities, a significant contribution was given through the activities undertaken by National Emergency system (fig. no. 8), which at the national level accomplish the following measures:

- Assure the organisation, supervision and control of the instruction activity of the population;
- Propose the allocation of technical and financial resources for assurance of the civil protection activity in optimum conditions;
- Were undertaken scientific researches, and designed instructions plans and researches themes in the field of civil protection activity.

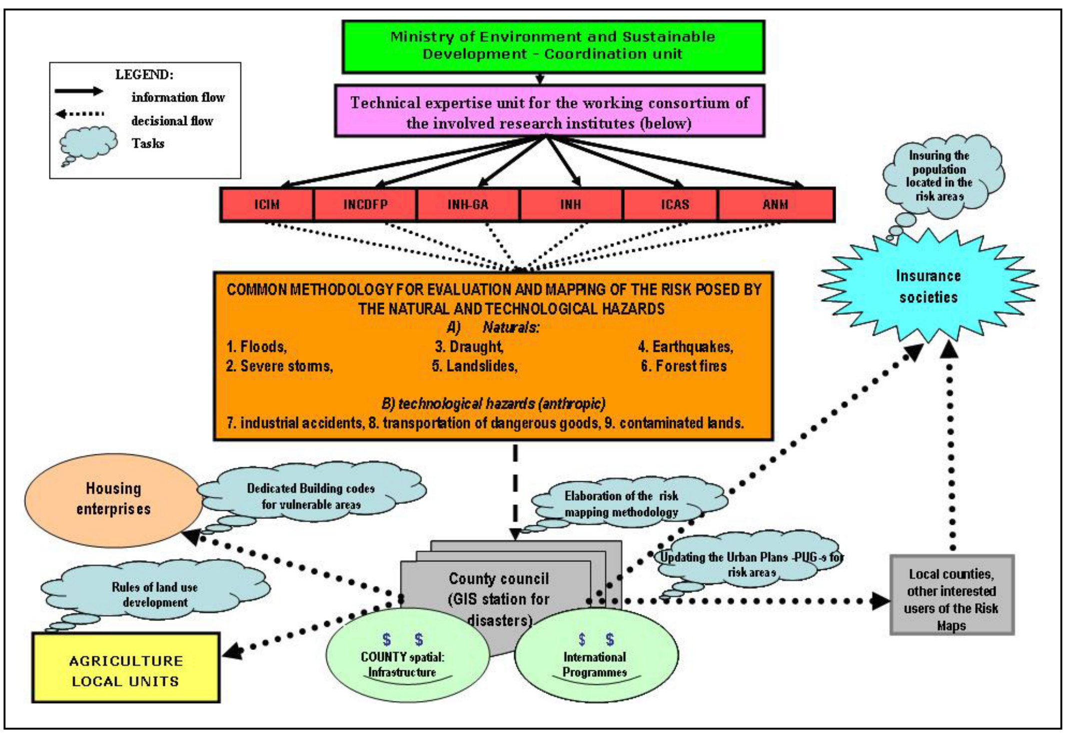


Fig.8 . Hazard mapping project scheme at the county level, involving the private insurance firms based on the risk maps (according with GD 447/2003), using GIS for the vulnerable areas at natural and technological hazards

3.1.2. Proposals for preventive activities to reduce natural and technological risks

The public consultation will be realized more efficiently by GIS maps for hazards from the county level, as a result of the information visualization regarding the new development for industrial facilities with increased risk for major accidents.

The result of the further projects using GIS hazard maps will make increase the responsibilities of the decisional factors involved in the territorial planning, for establishing the efficient programs for population protection, including development programs taking into account the existing risk from the concerned area. Also will led to promoting common projects at the level of the whole country.

Promoting a private insurance mechanism in order to cover the most part of the indemnity in case of disaster for the potentially affected people or institutions in Romania will lead to:

- Extending the interest of private companies for natural and technological disasters at the county level.

- Encouraging juridical and physical persons potentially affected by disasters to use private insurance company's services, not just public compulsory type, which didn't cover all type of hazards, but mainly earthquakes (Mara & Vlad, 2008a) and floods.

The most relevant ways in which the insurance societies can be involved in the reduction of the risk, are the promotion of working safety norms and by relocation of some economical and social activities in the low risk areas, through the insurance prime differentiated by risk classes.

3.2. Case study of a NATECH event type - a spilling mining pond located upstream a locality, incident during 2003

Tarnicioara tailing dam nearby the Calimani National Park, became a NATECH risk zone due to severe rainfall during the period 06.27.2006-07.02.2006. Heavy rainfall led to torrential flows on the slopes surrounding the dam from the north-east, which formed a temporary lake on the top of the tailings pile, threatening almost 5000 people located nearly 3 km downstream, in the village of Ostra, and is a part of the Calimani National Park, a particular natural reserve area where the activies with negative impact against the environment are totally forbidden, as indicated in the Fig. no. 10 (Mara et al, 2007e), below. The Tarnicioara tailing dam belongs to the mining company SC Minbucovina, and was decommissioned in 2001.

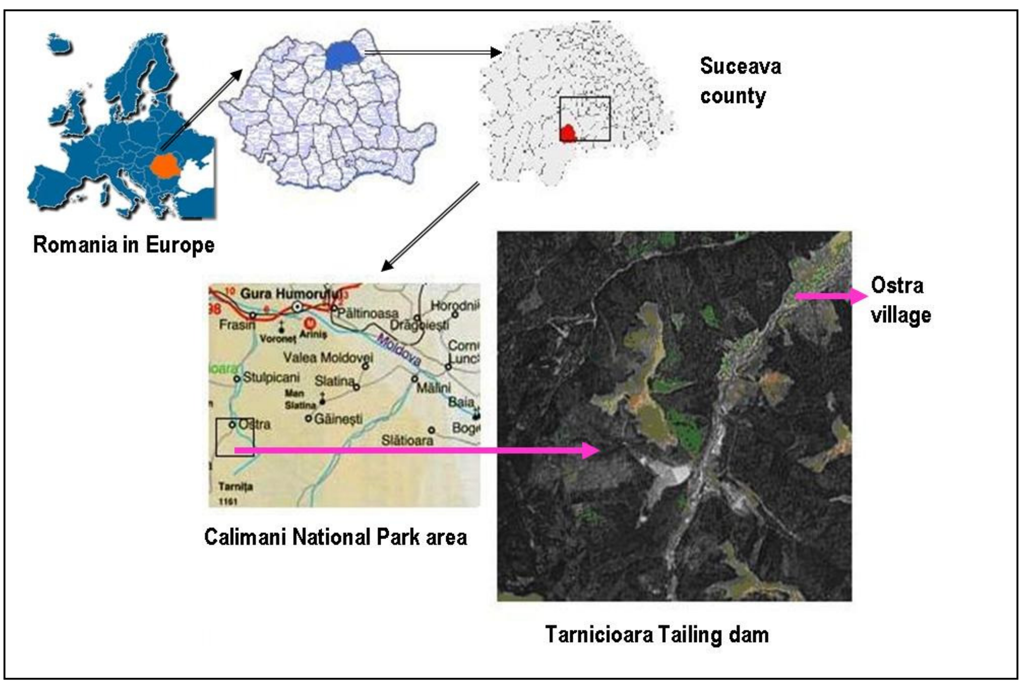


Fig. 10 Localization of the Tarnicioara tailing dam, 3 km upstream of Ostra village

Since decommissioning, the tailing dam has a significant impact on the quality of environment, because of heavy metal soil contamination downstream of the tailing dam, which are exceeding the thresholds for heavy metals, regarding Cu, Zn, Pb and As, mostly 30 cm below the surface. Therefore an imminent collapse of the dam could significantly worsened the environmental conditions, because of the presence of the heavy metals, well known as for the mutagenic, theratogenic and carcinogenic effects over the whole food chain, including human and biota (APM Suceava, 2005).

As a result of the heavy rainfall in the area of Tarnicioara tailing dam, during 27.06. - 02.07.2006, excess water from the nearby creek accumulated on the top of the tailing dam, creating a reservoir of 15 m water deep, as ilustrated in the Fig. no. 11, below. Because of the strong gusts of wind accompanying the heavy rain storm, large waves started to battered the tailing dam crest, creating a danger to overflow and flood the downstream village, Ostra, located at 3 km distance. The upstream water course, Scaldatori creek is normally diverted around the tailings dam via a tunnel; however, the stream overflowed the discharge tunnel, which was clogging with debris, branches, (fig. 12) being in danger to reactivate a sufozion from 2001.

Fig. 11 Temporary lake formed on the top of the tailing dam endangering the downstream inhabitants and tourists located in Ostra village, and Fig. 12: detail of the diverting tunnel of the creek from the upstream area of the tailing dam, partially blocked with debris)

3.2.1. Response activities for minimising the NATECH efects

The National Agency for Land Reclamation (ANIF) (fig. 13) put in place 6 special pumps normally used for flood control in irrigation systems, with a discharge over 1100 cm/h, and a higher capacity pump (1600 mc/h) from a coal mine, to remove the temporary lake formed on the top of the tailings dam, where was used an improvised log platform in order to unclog the drain of the lake, as shown in the Fig. no. 6, below. Also three additional pipes were installed upstream of the diverting gallery, in order to diminish the inflow to the tailing dam. These pump were operated at their entire discharging capacity, until the flooding phenomena was diminished. A combined team of specialists from Suceava Water Management System (county branch of “Romanian Waters” National Agency), Inspectorate of the county emergency system and Tarnita preparation unit took action at the dam for few weeks, until the normal flow within diverting tunnel was completely restored.

Fig. 13 Mitigation measures in order to evacuate the excess water from the top of the Tarnicioara tailing dam

3.3. Improvement the safety of the tailing dams exploitation for adaptating to the specific geotechnical conditions in Romania

3.3.1. Land stability conditions specific of Romania

The spreading of landslides in Romania with severe damages as a result of recuent reactivation due to related geo-hazards factors, i.e. meteorological, hydrological, etc., and their complexity in term of dynamic, extent, causes and evolution, induced the increasing concern of specialists and risk managers, for a justified interdisciplinary research of real cases, taking into account also methodological aspects with general appliance.

A brief assessment of this kind shows that the ground affected by active landslidesin Romania covers a surface of 115,000 ha (Bălteanu, 1999), caused by the following factors:

- The stability of the land depends on permanent and sporadic factors, which influence the development of the landslides (Wolkersdorfer & Thiem, 1999). The permanent factors are represented bygeneral geological and geomorphologic conditions. The sporadic factors are representedby the local conditions of landforms, climatic, hydrologic, seismic, forestry, and anthropogenic type.
- In Romania, the landslides and other types of land movement or block fallings are connected particularly to slope rock composition and linked to climatic regime. The most frequent types of landslides are associated with the network of erosion of subjacent rockmaterial, and the mudflows with the surface erosion on an advance stage.

3.3.1.1. Methodology of drawing maps of landslide zoning due to aggravating geohazards for the Romanian territory, at the local and administrativ level

As a result our analyses, in recent years the severity of the extreme meteorological phenomena significantly increased, linked with global warming and climate changes, i.e. heavy rains which led to historical floods on the most part of the hydrographical basins of Romania, mostly during 2005 and 2010 ***(Fig. 14),*** and reactivated many landslides.

Recently, based on the common Order of Ministry of Agriculture, Forests, Waters andEnvironment and Ministry of Transportation, Constructions and Tourism regarding the delimitation of the areas prone to natural risks (no. 62/N-19.0/288-1.955/1998), earthquake, landslides and flooding risk areas from Romania are established (Official Journal no 354, part I, from 1998), at the level of the whole country and by countries, represented on maps at the scales 1:25,000 and 1:5000. A major contribution has been carried out bz the National Geological Institute, which completed and updated the data base regarding the active or reactivated landslides from Romania, which also impact the waste dumps from mineral resources exploitation (generally mining tailings with stability problems, from coal ore areas).

We propose that this Methdology to be used for representation on thematic maps the hazard environmental factors, landslides, by the Law regarding the "Plan of the national territory development", the Fifth section – Areas of natural risks" (no. 575/2001)- natural "risk zones", aplicable also at the tailing ponds (Mara & Vlad, 2008d).

In order to prevent and mitigate the effects of natural disasters, such as landslides and floods, measures to minimize the socio-economic impact are to be taken and have to include:

- Delimitation of all the areas where building is prohibited, in the documentation of urbanism and planning;
- Obligation to conduct geological surveys, including laboratory and in situ geotechnical tests, in order to know the properties of the soil and bedrock of the populated areas and those with a socio-economic activity;
- Implementation of special building rules, which have to take into account the existence of natural hazards in the area;
- Measures for prevention and reduction of natural risks have also to be implemented, also for mining tailing dams, active or under conservation. They have to consist of the followings:
- Maintenance of the facilities for protection and mitigation of natural disasters;
- Control of the degree of land occupation and the completion of the specific land use and building plans;
- Information of the population regarding the potential risks specific to their respective inhabited area.
- Systematic forecast of heavy rains since intense rainfall is one of the major landslide triggering and reactivation factors.

Fig. 14: The areas prone to flooding, especially with step relief, nearby water courses, are subject to frequent landslide due to erosional and solid transport

3.3.1.2. Methodology of drawing maps of landslide zoning at the national level

We consider that is necessary the implementation of preventive measures at local level, structural (reforestation, floodplain forest rehabilitation, protection works of banks, eg.) and nonstructural measures, in the field of legislation, to limit the impact of specific activities such as the extraction of gravel, cutting floodplain forests eg. We propose that these measures be applied mainly in the areas with increased risk due to the presence of tailing ponds and hips from mining industry.

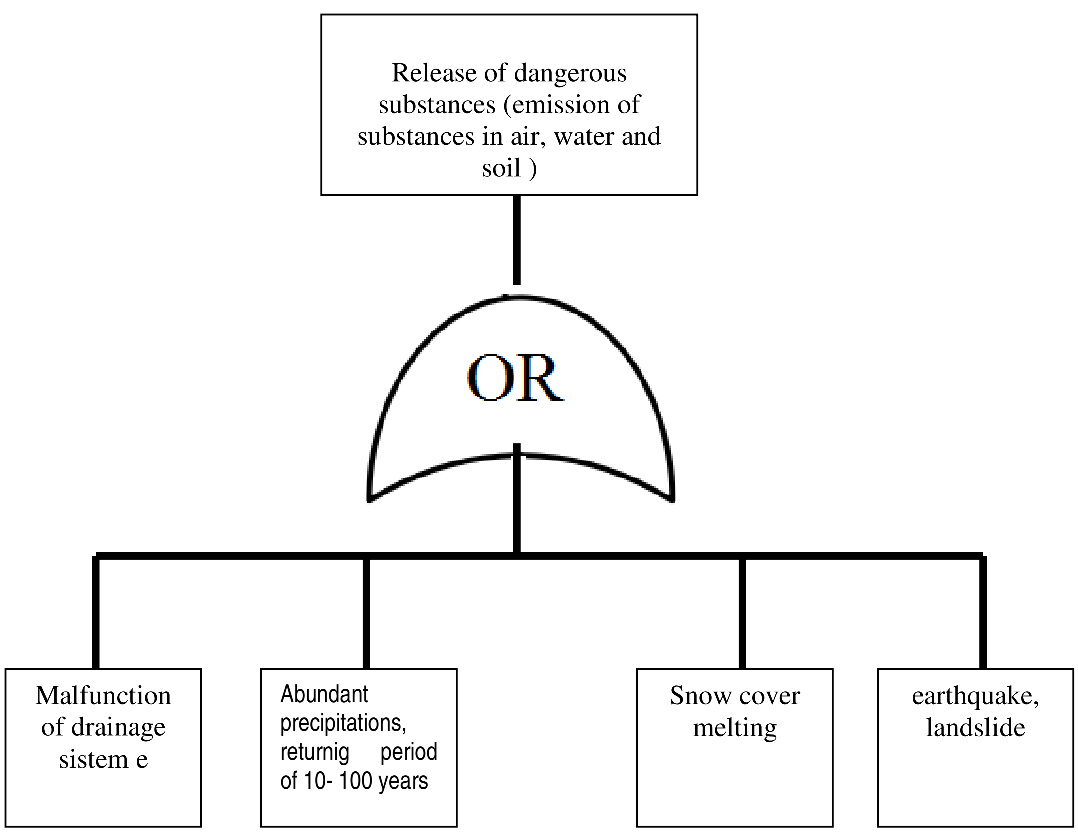
The vulnerability reduction of the areas prone to landslides, especially the slopes zones, located in the vicinity of socio-economical activities, such as transportation routes, inhabited areas, plants, etc., is recommended by structural measures. These measures should include reforestation, which can improve the slope stability, through restricted investments compared to other correction procedures (diverting the roads, expensive consolidation works, such as supplementary embankments, slope angle reduction, etc.) according to the risk map zonation.

In order to prevent and mitigate the effects of natural disasters, such as landslides and floods (Vutukuri & Singh, 1995), measures to minimize the socio-economic impact are to be taken (Mesescu & Mara, 2011), and have to include:
- Delimitation of all the areas where building is prohibited, in the documentation of urbanism and planning (cf. PUG).
- Obligation to conduct geological surveys, including laboratory and in situ geotechnical tests (Pigati & López, 1999), in order to know the properties of the soil and bedrock of the populated areas and those with a socio-economic activity (Andreichuk et. al., 2000);
- Implementation of special building rules, which have to take into account the existence of natural hazards in the area.

3.5. Case study of a NATECH event type: landslide at North Pang waste dump, located nearby Turcesti village, Mateesti commune, county of Valcea. – 09.02.2008

In our study, we identified the mechanisms of accidents / incidents occurred at tailing ponds in Romania in recent years (risk analysis) (***fig. 25***):

Fig.25 *Main failure mechanisms at the tailing dams from Romania (event tree, for accidents/incidents)*



4. Methodology to quantify the hazard associated of tailings dams

The methodology now being used to assess the hazards associated with industrial or mine waste tailings dams is based on quantifying the hazardous components and assigning a hazard value, using a system of criteria, indexes, and notes (Mara et al., 2006).

Indexes used in the evaluation of dams and deposits are (NTLH-021):

1) The BA index is determined by the dam's or deposit's characteristics (dimensions, type, discharge, importance class), it's location (the nature of the ground and seismicity), and the condition of the lake or waste deposit;
2) The CB index is determined by the situation of the dam, the sophistication of the operational controls and monitoring system(s), the level of maintenance, the dam's behaviour over time, the conditions of the accumulation lake, and the level of site-specific knowledge; and
3) The CA index quantifies the consequences of damage to the dam/deposit, taking into consideration: the possibility of loss of lives, potential effects on the environment, potential social-economical effects, etc.

The hazard associated to a dam is appreciated by the RB index**:**

$$RB = \frac{CA}{\alpha \times BA + \beta \times CB} \qquad \text{(Eq 1)}$$

In which the weight coefficients α and β have the values:

$\alpha = 1$ for dams and deposits that have been established according to the current provisions;

$\alpha = 0.8$ for dams and deposits that have been established based on older regulations;

$\alpha = 0.4$ for situations in which there is a lack of adequate data regarding the project;

$\beta = 1$ for dams or deposits that have had no problems during or since construction;

$\beta = 0.7$ for dams or deposits that had incidents or accidents during or since construction, resolved through supplementary works.

Depending on the value of the RB index, the dams are assigned to one of four hazard categories (A, B, C, or D):

$RB > 0.8$ – a dam of exceptional importance (A)

$0.8 \geq RB > 0.15$ – a dam of special importance (B)

$0.15 \geq RB > 0.05$ – a dam of normal importance (C)

$RB \leq 0.05$ – a dam of low importance (D)

4.1. Estimation of vulnerability of tailing ponds from mining industry

The new alert thresholds for water pollution recently issued in the framework of the Danubian Accident Emergency Warning System (AEWS) of the ICPDR in 2005 are leading in Romania to an improved approach to environmental safety and improved water protection regarding the safety of each owner of dangerous substances for water,which can produce accidental pollution.

This above related issues, means improvement of the water protection and the public opinion over the measures taken by the responsible authorities responsible for the the water management problems (Mara et. al 2008).

If the nature and concentration of the discharged dangerous chemicals stored in a tailings dam is known, alert thresholds can be assessed for water pollution incidents using the international Danubian AEWS based on emissions.

For calcuation of WRI, the hazardous/potential dangerous substance, released into a water stream, will be firstly expressed in a Water Risk Class (WRC), based on WRC 3 and the 10 based logarithmic value of the summarized value, will constitute the WIR, as it follows:

$$WRI = \log\left(\sum WRC\right) \qquad \text{(Eq 1.1.)}$$

We consider that the Water Risk Index (WRI) value, can be assimilated with vulnerability to accidental pollution of the tailing dams, being a very important factor to be considered when estimating the overall risk of a tailing dam accident, after the initial quantifiquation of the hazard.

4.2. Evaluation of the risk for transboundary pollution, for the mining tailing dams

We consider that the risk of tailing dams to surface waters can be defined as (eq 2.):

Risk = Probability x Vulnerability = $RB \times WRI = \dfrac{CA}{\alpha \times BA + \beta \times CB} \times \log\left(\sum WRC\right)$

This risk evaluation methodology, once applied for the first time, at the national level for the tailing dams in Romania, and will bring the following advantages:

- allow risk managers to better evaluate the relative threat posed by varied levels of various potential contaminants to the environment from the tailing dams, differing to the conventional installations storing chemical substances, very vulnerable to the surface water and surrounding environment (Mara et. al, 2010);
- improve projected evaluations of potential damage and the social-economical impact in case of an accident at a tailing dam;
- the issuing of safe operation permits for tailing dams from the mining and chemical industry, will allow an increased safe operation;
- allow managers to develop safer operating procedures for tailings dams; identify potential hazard sources and accident scenarios related NATECH events for tailings dams.

4.2.1. Case study of an incident with hazardous substances associated with mining waste (pollution of a tributary of the River Tisza with cyanide, 25.11.2005)

We identified as important for significant lessons to be learned, the following case study:

<u>*Event description*</u>: accidental spill of an ammount of cyanide (bellow the threshold level) into a tributary of Tisa River.

Event chronology

- on 25.11.2005, hour 8:00, a technical accident occured at Mining Exploitation E.M. Baia Borşa (CNPMN Remin SA Baia Mare). The event isn't announced by the plant, according to the legal procedures, to the responsible authorities;
- on 26.11.2005, hour 10:30 , Water Management System (S.G.A.) from Maramureş county, was announced about the occurence of a fish death on the River Viseu, by the mayor of the village Bistra. The specialised personell went to investigate in the area of Bistra Village, since 14.30 hour, where is confirmed a fish death, bu the there are no organoleptic disfunctionalities of the water course. Withouth beeing identified the cause of the death fish, in the area where was observed, the specialised personell from SGA Maramures and Environemtal Guard from Maramures county, moved to check the downstream area of the River Visu and the control of the potential pollution sites. The lenght of the river course which have to be verified was about 70 km, including parts of main tributaires, Ruscova River and Vaser River.

<u>*Technical data of accident occurence:*</u>

Name of the chemical substance: Sodiumcyanide (***tab. 13***)

Tab. 13 : chemical characateristics regarding the water pollution chemical risk of the substance:

Dangerous substance	Maximum quantity /spilled quantity	Seveso Category	Art. 6 şi 7 (column no 2) from the Seveso Directive - quantity tonnes	Art 9 (column no 3) from the Seveso Directive - quantity tonnes	Risc phrases	Physical status
(Sodiumcyanide) NaCN	0,3 (tons)/ 0.098 (tons)	1, 9i,	5	20	R26 R27 R28 R32 R50 R53	liquid

- Seveso Category:

1 Very toxic

9i Very toxic to aquatic organisms

- Explanation of R–phrases:

R26 Very toxic by inhalation

R27 Very toxic in contact with skin

R28 Very toxic if swallowed

R32 danger of cumulative effects

R 50 Very toxic to aquatic organisms.

R 53 may cause long-term adverse effects in the aquatic environment

Molecular weight: 49,0072 g/mol

Toxicological data:

ORL-RAT LD50 6.4 mg kg-1 - oral absortion in rat

IPR-RAT LD50 4.3 mg kg-1 - intraperitoneal rat

SKN-RBT LD50 10.4 mg kg-1 – dermal rabbit

4.3. Procedure for establishing the threshold values for warning-alarming the accidental pollution caused by a hazardous substance

Procedure description

Until 2004, in the frame of the Danubian riparian countries (ICPDR), was considered as unique criteria for alarm initiation at accidental pollution, the overexceeding the admisible limit value of certain water quality specific parameters. Since 2005 was taken into consideration another approach, so the inititation of the alarms is permited even the values of the pollution parameteres are below the admissible values, in order to better ilustrate the damage of the water quality status (which in the case of certain substances, for example petroleum products, was difficult to detect the maximum value of the pollutant concentration, or in other cases in which were not performed enough chemical analyses in order to suprise the maximum of the pollutant plume, in order to give a real image of the phenomenon).

For all the cases of acute polution of the waters of the Danube River, in the case when the quantity of the released polluted substances in the water is known or can be estimated, the following tables (***tab. 14.a* şi *tab 14.b.***) offer a safe base for taking decissions in order to activate the warning system in Danube Basin AEWS, by sending a alarm mesage to the potential affected countries.

The pollutant subtances, released in surface water during a pollution event, have to be firstly classified in Risk classes (WRC[1]) according to the German data Base of hazardous substances to water, ("Katalog Wassergefährdender Stoffe) or by the Risk criteria R (Risk phrases R[2]). The quantity of pollutant expressed in Risk classes (WRC), has to be compared with the corresponding alert threshold (***Tab. 14.a.***). In case of overexceeding the threshold values, a Warning message type, will be send by the PIAC of the respective country where the pollution event took place, towards the PIAC of the country located downstream.

Risk classification is done on a scale of 0-3 as follows:

- WRC = 0 – in general non-hazardous to waters
- WRC = 1 – low hazards to waters
- WRC = 2 – hazard to waters
- WRC = 3 – severe hazards to waters

Assessment of the Water Risk Index – W.R.I.

The Water Risk Index (WRI) value is equal with the 10 based logarithmic value of the summarized equivalent values of the WRC based on WRC 3, of the quantity expressed in kg (or liter) of released hazardous chemical.

---

[1] Valorile WRC (în limba germană: valori WGK) sunt disponibile pe site-ul:
- http://www.umweltbundesamt.de/wgs/wgs-index.htm
- (Katalog wassergefährdender Stoffe, LTwS Nr. 12, Umweltbundesamt 1991)

[2] Directiva 67/548/EEC ff (privind manipularea, ambalarea şi transportul substanțelor periculoase).

Calculation procedure:

(1.) Calculation of the WRC equivalent values of the hazardous substance:

in accordance with German datatabse of hazardous substances to waters[1], the values are the following:

Eg: Sodiumcyanide……..3.

(2.) Calculation of the global risk index WRI

For calcuation of WRI, the hazardous substance will be expressed in a Water Risk Class (WRC), based on WRC 3 and the 10 based logarithmic value of the summarized value, will constitute the WIR.

Quantity (kg)	WRC value	WRC equivalent quantity
M	0	$M \times 10^{-3}$
M	1	$M \times 10^{-2}$
M	2	$M \times 10^{-1}$
M	3	M

Calculation of the WRC equivalent values is made on a practical example:

(3.) Assessment of the Water Risk Index (WRI)

The WRI value is the 10 based logarithmic value of the summarised WRC equivalent values.

Tabel. 14.a Alert thresholds for water pollution for the hydrographical basin of Danube River

Substance classifications	Alert thresholds	
Water Risk Class (WRC)	Intake stream Discharge Qm < 1000 m^3/s	Intake stream Discharge Qm ≥ 1000 m^3/s
	WARNING to be issued [kg] or [l]	WARNING to be issued [kg] or [l]
"0"	≥ 100 000	≥ 1 000 000
1	≥ 10 000	≥ 100 000
2	≥ 1 000	≥ 10 000
3	≥ 100	≥ 1 000
Water Risk Index (WRI)	≥ 2	≥ 3

The lessons learnt resulted from the previous accidents, indicate the presence among oil products, in many cases of the waters resulted from the fire extinguished actions, the mining waste water mixed with considerable amount of sterile with various contents of heavy metals, sludge and the manure waste waters . Therefore a separate approach is considered for the most common water contaminants (tab. 14.b).

The lessons learnt resulted from the previous accidents, indicate for petroleum products, sludge and wastewater, most frequent accidental pollutions are due to mineral oil or petroleum products, which in most cases are not specified.

Also, the fire water, sewage and wastewater from farms are common, as specific pollutants (***tab. 14.b***).

We identified that mining tailings, if not contain heavy metals, may be included in this category, of the sludge, because in contact with water, tailings look like a diluted mud, producing the same pollutant effect (increased turbidity).

Tabel 14 . b. Various contaminants – Water Risk Index values

Released substance mixture	Warning to be issued [kg] or [l]	Warning to be issued [kg]or [l]
	Intake stream discharge Qm < 1000 m3/s	Intake stream discharge Qm > 1000 m3/s
Oils (non-specified)	≥ 1 000	≥ 10 000
Quench water / fire	≥ 10 000	≥ 100 000
Slurry, and Sewage (animal)	≥ 10 000	≥ 100 000
Suspended ash *(sterile withouth heavy metals)*	≥ 100.000	≥ 1.000.000
Water Risk Index (WRI)	2	3

Case study: cyanide pollution from 25.11.2005, withouth transboundarz effect

Water risk index assessment for the incident from November 2005 (cyanide pollution) of the Viseu River

The Water Risk Index (WRI) value is equal with the 10 based logarithmic value of the summarized equivalent values of the WRC (based on WRC 3), of the quantity expressed in kg (or liters) of released hazardous chemical .

Based on the accidental pollution allert threshold criterias (ICPDR, 2005), in conjunction with mining tailings assimilation as a sludge from sewage (from the point of view of effects on polluted tributary) we have identified the following calculation procedure that can be applied to all transboundary accidental pollutions from mining activities:

Example for a spill of 98 litters of liquid sodium cyanide (Na(CN))

(1.) Calculation of the WRC equivalent values of the hazardous substance

Utilizând directorul german al claselor de risc pentru apă, valorile sunt următoarele: valorile WRC sunt:

Sodiumcyanide……..3.

(2.) Assessment of the Water Risk Index WRI, for the quantity spilled

For WRI evaluation firstly will be expressed in WRC equivalent values, based on WRC 3, and the 10 based logarithmic value of the summarized equivalent will constitute the WRI.

Quantity (kg)	WRC value	WRC equivalent quantity
M	0	M x 10^{-3}
M	1	M x 10^{-2}
M	2	M x 10^{-1}
M	3	M

Cas-Nr = 143-33-9, EG-Nr 205-599-4, WGK (în German)=3

Calculation of the equivalent values of WRC of sodium cyanide:

Quantity (kg)	WRC value	WRC equivalent quantity
M_1= 98 kg	3	98 kg
M_1 =		98 kg

(3.) Calculation of the Water Risk Index (WRI)

WRI is the 10 based logarithmic value of the summarized equivalents, which in our example is:

log 98 ≈ 1,99, it's a value which didn't exceed the treshold limit value of 2 (***Tab.14.b***);

Conclusion: no warning needed (according to ***Tab 16***).

The input value of 98 kg of Na(CN), was extrapolated from the data revealed by the mass load of the flow of water of the River Tisa at Teceu control section (located at the border with Ukraine, Fig.27) for the constant value of the flow equal with 34 mc/s) Without taken into consideration the contribution of the natural fond of the river (indicated by the values surprised before the arriving of the contaminant plume arrival, illustrated with a red line, (Fig. 26), the water quality status would have been indicate a superior value, necessitating alarming (Tabel. 15). This superior pollutant load value, could have been constituted a false value, which could have been generated the payment of compensation to the downstream countries, because of the effects of this wrong action (like the expenses for water quality analyses, operational costs of shut down the inhabitants water supply, eg.)

Table.15. Calculations of the total sodiumcyanide CN- loads spilled in the Tisza River based on the concentration measurements, on a spreadsheet formula (through the tributary Viseu)

hour	**CN- mg/l**	**Q (cm/s)**	**Mass flow of CN- (mg/s)**	**time – step of mass flow - s**	**Loads of CN- in water= time -s x mass flow -kg/s**
1:00	**0.002**	**34**	**68**	**2h=7200 s**	**0.4896**
3:00	**0.036**	**34**	**1224**	**2h=7200 s**	**8.8128**
5:00	**0.041**	**34**	**1394**	**2h=7200 s**	**10.0368**
7:00	**0.053**	**34**	**1802**	**2h=7200 s**	**12.9744**
9:00	**0.044**	**34**	**1496**	**1h30m=5400s**	**8.0784**
10:30	**0.033**	**34**	**1122**	**1h=3600s**	**4.0392**
11:30	**0.021**	**34**	**714**	**2h=7200 s**	**5.1408**
17:00	**0.005**	**34**	**170**	**6h=7200s x 3**	**3.672**
					Σ=53.244 kg

Total contribution of Na(CN)= 2 x 53.244 = 106.448 kg - Alarming necessary;

But

Natural (fond) contribution to the total load = 0.002 mg/l, CN- detection limit x propagation time (16 h) =*3.9168 kg;*

Results:

Total contribution of Na(CN) without natural input = 2 x 49.3272 = 98.6 kg;

Tab. 16 Online alert threshold calculation through ICPDR-AEWS website (www.icpdr.org/aews)

Alert thresholds for the Danube River Catchment

Input values:	**Flow rate**	34 m³/s		
	Emission	**Quantity** (kg or l)	WRC	Substance mixture
	Substance 1	98		←
	Calculate	Reinitializare		
Output values:	**Equiv. quantity**	98 kg or l		
	WRI value	1.99		
	WRI threshold	2		
	Alert?	No Alert need		

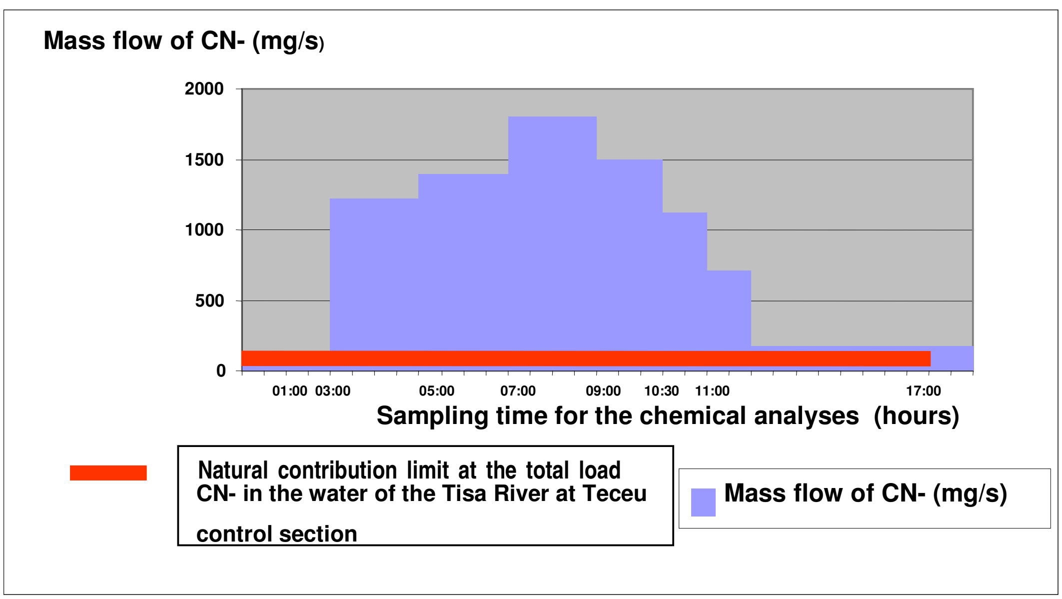


Fig. 26. Variation of the Mass flow of CN- (mg/s) Tisa river (Teceu control section following the accidental spill from 11.26.2005, 12:00, as result of the plume propagation following the incident from Mining Exploitation EM Borsa

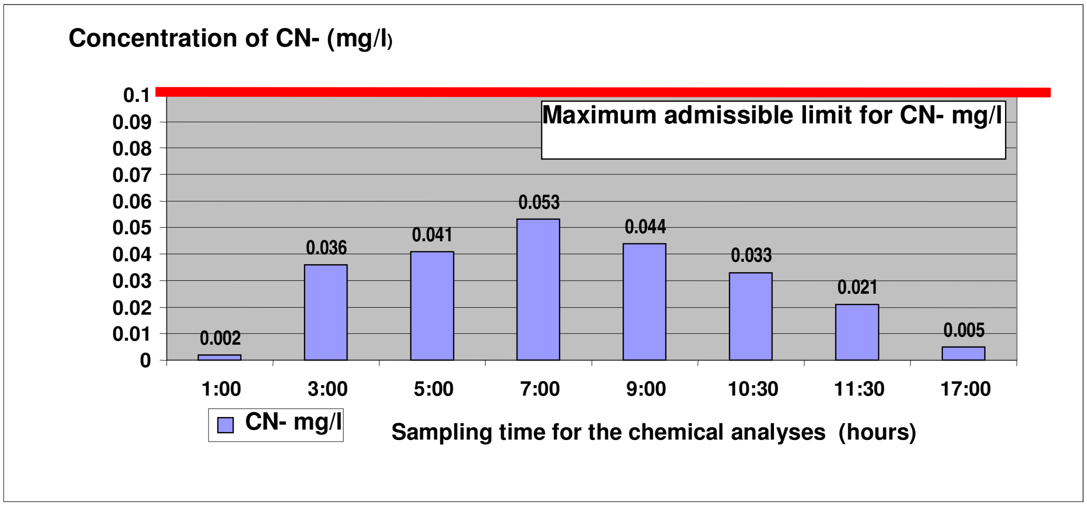


Fig. 27. Variation of the content for cyanide CN- (mg/l) in Tisa river (Teceu control section) following the accidental spill from 11.26.2005, 12:00, from Mining Exploitation EM Borsa

<u>General considerations</u>

The new alert thresholds for water pollution recently issued (emissions) in the framework of the Danubian Accident Emergency Warning System (AEWS) of the ICPDR are leading, in Danubian countries, including Romania, to an improved approach to environmental safety and improved water protection, by taking into account pollution which shouldn't be anymore neglected, event the concentration of the pollutant in the water is below the maximum admidissible level (as previously considered, unitl 2005).

We concluded, as a result of our analyse, that for avoiding further accidental pollutions, similar to that one from Tisza river, it have to be taken also some precautionary measures at the level of the industrial facilities as it follows:

- An increased frequency of the periodical inspection at the dangerous instalations, for assuring the safety activities of handling, tranfer and storage of the dangerous substances;

- Existance of more accurate and updated inventory of the dangerous substances, located at the industrial facilities in order to know exactly the spilled quantities based on the difference of the quantities located at the storage and the registred quantities.

- Information dissemination regarding the new ICPDR methodologies for establishing the alert thresholds in case of accidental pollution, through the involved authorities in the water quality management and other establishments which managed those substances (Mara, 2006).

- Endowment with propagation models for inner rivers (***Fig. 28***) for a rapid evaluation of the concentration plume in the surface waters, very useful for establishing the necessary measures for pollution control (assurance of a dilution below the alert thresholds, controled sampling knowing when the pollutant maximum concentration reach the control section, reducing the cost of the monitoring activity, etc.)

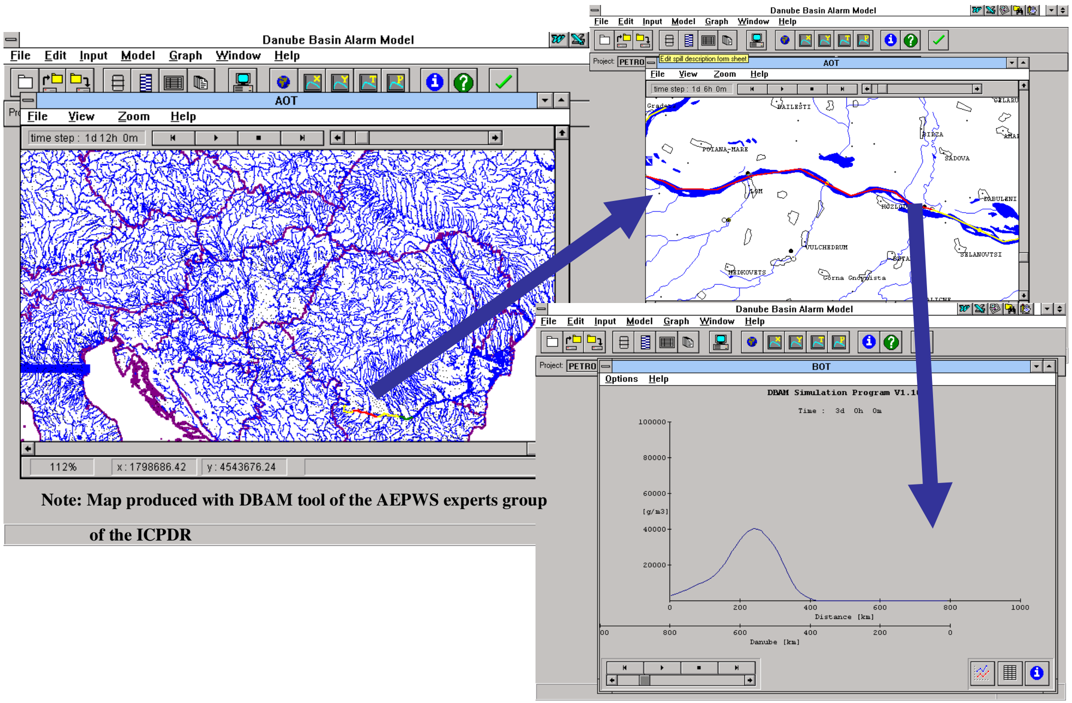


Fig. 28. PIAC tools – DBAM model , Danube Basin Alarm Model (preview)

4.3.1. Concluzions regarding the introductions of the new alert thresholds for acciddental polutions

In order to avoid any further accidental pollutions, is necesary to be established precautionary measures, at the level of the industrial units, for information dissemination regarding the new ICPDR methodologies for establishing the alert thresholds in case of accidental pollution, through the involved authorities in the water quality management and other establishments which managed those substances.

4.4. Metods for transboundary water quality monitoring for identification of the accidental pollutions caused by mining activities

The main parameters taken into consideration in designing the environmental quality objectives for the monitoring of the water quality are as following:

1) f (s,t) – spatial-temporal evolution of the concentration;

2) Li= f (s,t) - spatial-temporal evolution of the associated loads;

3.1 $\frac{C_i}{C_i^s} = f(s,t)$ - spatial-temporal evolution of the compliance with the quality standards;

3.2.) $Li/Qo = f(s,t)$ - spatial-temporal evolution of the observance of the quality objectives;

4) operative warning in case of an accidental pollution.

One of the main function of surveillance regards the operative warning in case of accidental pollution (Mara, 2004).

4.4.1. Characteristics of water quality monitoring system in Romania

A national system for the information management, assured by the National Administration “Romanian Waters” – ANAR is operational for the prevention of the accidental pollutions. In addition the collection of the information is conducted by permanent monitoring of water quality courses.

The National System of Water Quality surveillance was developed during 1975 –1979, based on 5 subsystems: surface water quality, lake water quality, groundwater quality, waste water and marine water. The system generally had the same structure, with a series of improvements after 1990’s (increasing number of determinants, investigated matrix, etc). Despite many accidental pollutions before 1990’s, any definition of the accidental pollution was not agreed, and therefore not recorded systematically.

4.4.2. Stage of the transboundary water quality monitoring

In the border sections of watercourses flowing from Romania into downstream Hungary, the water quality in the past 10 years was improved and the analysis of status was evaluated according to 5 quality classes classification system within the common Romanian-Hungarian Regulation ***(Tab. 17).***

Table. 17 *Dissolved oxygen is used as a main parameter for identifying the pollution problems of transboundary waters in NW part of Romania*

Water quality parameter	Unit	Class limit values				
		I.	II.	III.	IV.	V.
A/ Parameters of oxigenation						
O2	mg/l	>7.0	6	4	3	<3.0

The analysis is based on the average values of water quality parameters, the 10% percentile of dissolved oxygen and the 90% percentile of other components.

Data used in analyses and evaluation are the results of the joint examinations performed by the partners, as prescribed by the “Rules concerning the Water Quality Monitoring on the Border Water bodies or on the Shared Border Water bodies”.

The water quality of watercourses is determined by natural and anthropogenic pollution loads. The quality of waters arriving to the Hungarian-Romanian border section depends essentially on the pollution in the trans-boundary regions.

Water quality of the watercourses in the Hungarian-Romanian border region showed a generally improving tendency since 1993. The evaluation of the transboundary water quality trend was based on the 10-year values of the main water quality components, especially for Dissolved oxygen contents (O_2), which varied between 1.3 – 8.4 mg/l, and showed an improvement on the main cross-border Rivers.

Generally the most important weight of the potential pollution sources of the surface waters is represented by the local comunities, chemical industry, followed by the mining industry and metalurgy; in case of an accidental pollution ***(Fig. 30),*** the mining industry contribution might prevail (Mara 2009).

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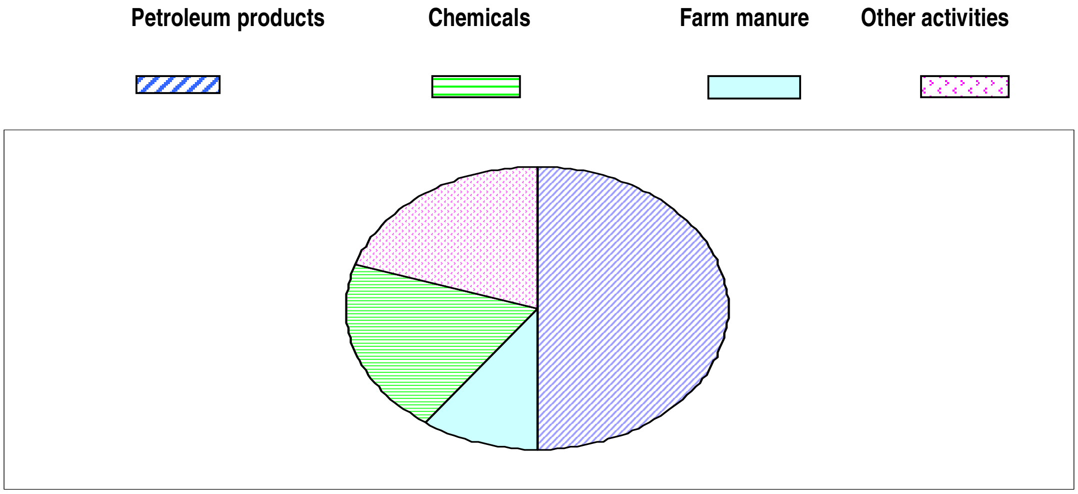

Fig. 30 The weight of different activities at the contribution of the accidental pollutions of surface waters in Romania (the source of information – PIAC activity, Principal International Alert Centre)

AEWS (Accident Emergency Warning System), through his own PIAC, with the decisional unit located at the Ministry of Environment of Romania, constitutes a meeting point of all measures and initiatives in the Danube Hydrographical Basin. It is imperative for Romania the implementation of the EU Water Framework Directive, regarding the improvement of the water quality status, a condition for assuring a better standard of water services for population and environmental preservation, for a safe living inside the European space. The efficiency of the Romanian PIAC was firstly proved during the Kosovo war, in spring of 1999, when communicated the state of the Danube at the entrance in Romania, due to contradictory news about the NATO bombardments on economical objectives and refineries on the Danube banks (Novi Sad, Pancevo),

Furthermore, the new alert thresholds for water pollution in the framework of the Danubian AEWS (ICPDR, 2005), which are going to be applied as a national environmental methodology, coupled with an improved pollution propagation model will lead to an improvement of approaches related to the safety issues for each owner of dangerous substances for water, in order to improve the water protection and the public opinion over the measures taken by the responsible authorities involved in the water management problems. Based on the information from the water quality automatic monitoring system, disseminated in due time to all organizational structures at national, regional and local level, operative actions against the accidental pollutions could be taken properly. Forecast of the pollution is elaborated using appropriate models if an accidental pollution emerge, and all downstream water users are announced depending the pollution degree, the water intakes are closed, for protection the population and water users.

4.4.3. Prevention of the technological accidents in the transboundary context

The feasibility studies shows that the investment and operating costs of a monitoring system coupled with warning and alarming procedures are less expensive then the potential damages occurring due to accidental pollution with trans-boundary impact (Mara & Vlad, 2010). Enhanced co-operation with neighboring countries in the water management and environmental protection field is attested based on effective measures undertaken for waters disaster prevention and mitigation, especially by modeling the contamination propagation.

4.5. Legal aspects of the risk management of the tailing ponds

The measurement of the risk associated to natural hazards requires the use of a unitary system of procedure, for better correlation of the characteristics of different locations and their potential hazards. In order to manage such risks, the tailing dam owners have to assure proper operating programs, by implementing adequate measures to reduce the risks of an accident. The type of the required assessment can vary, based on the degree of potential risk and their potential environmental impact. A useful tool for the mining companies must be the use of a common methodology based on quantification of the risk components and on specific standard system of criteria, indices, and notes.

So, at national level, for each tailing dam, a ranking of natural hazards that could affect earth stability (such as floods, earthquake, landslides and freeze-thaw)should be done. This approach could lead to the prioritization of needs and measures to be used by local or national authorities involved in natural or anthropogenic risk management. In addition, GIS maps may expose the potential adverse effects of landslides which can trigger NATECH multiple cause disasters. So far, this type of disaster was not commonly investigated in Romania. Even the use of multiple-hazard recognition is relatively recent in Romania, representing a new trend of research, with significant applied implications, in correct evaluation of the risk associated both of natural and technical hazards .

In order to prevent and mitigate the effects of natural disasters against the tailing dams, such as landslides, earthquakes, floods, severe rainfall, and freeze-thaw phenomena, legal measures to minimize the socio-economic impact are to be taken and have to include:

- Delimitation of all the areas where building is prohibited, in the documentation of urbanism and planning (cf. PUG above).
- Obligation to conduct geological surveys, including laboratory and in situ geotechnical tests, in order to know the properties of the soil and bedrock of the populated areas and those with a socio-economic activity.
- Implementation of special construction rules, which have to take into account the existence of natural hazards in the area.

Measures for prevention and reduction of natural risks have also to be implemented. They have to consist of the followings:

- Maintenance of the equipment and works for protection and mitigation of natural disasters.
- Control of the degree of land occupation and the completion of the specific land use and construction plans.
- Information of the population regarding the potential risks specific to their specific inhabited area (Mara et al. 2006).
- Systematic forecast of heavy rains since intense rainfall is one of the major collapse triggering factors, which might affect the tailing dams.

The lack of field studies, the absence of laboratory research, the lack of knowledge of the real situation from the point of view of stability and the characteristics of the usual ground parameters in the areas where it is intended to design and execute any type of tailing dams, can lead to NATECH failures producing countless material damages and sometimes human losses.

Therefore we are proposing also a NATECH failure index in order to describe properly the collapse event susceptible for every tailing dam, as it follows (table no. 18).

The total value of the NATECH FC index is obtained by adding the values assigned to each criterion. It has to be specified that for every partial criterion, the appropriate number correlating parameter has to be chosen, in order to best describe the criterion. If parameters from two columns apply to the criterion, the lower numerical value has to be chosen.

Tabel 18: *Description of the NATECH failure consequences Index (FC) proposed for tailing dams*

Partial Criteria	Parameters and Indices			
1 population density in the downstream area	more than 20,000 inhabitants	300 to 20,000 inhabitants	scarcely populated	no population
	20	**10**	**5**	**0**
2 warning and alarm system	none	alarm system for local authorities	alarm system not tested or adapted by civil defence authorities	alarm system in place and tested by civil defence authorities
	20	**10**	**5**	**0**
3 Hazardous potential of the tailing dam waste material	mining tailing dam with dangerous toxic substances	Mining tailing dam with hazardous substances	Mining tailing dam with large quantity of inert sterile waste	only mining tailing dam
	20	**10**	**5**	**2**
4 economical entities in downstream area	industries with more than 100 employees	small industries	private workshops	no industrial activity
	10	**5**	**3**	**0**
5 land use around dam	agriculture	forests or pastures	uncultivated, barren	
	10	**5**	**0**	
6 environmental impact of potential failure	ecological disaster	significant effects	negligible effects	
	5	**3**	**1**	
7 effects of potential failure on river basin	failure of downstream cascade	jeopardising of flood control	no effects on flood control	
	15	**7**	**2**	

The total value of the NATECH FC index is obtained by adding the values assigned to each criterion. It has to be specified that for every partial criterion, the appropriate number correlating parameter has to be chosen, in order to best describe the criterion. If parameters from two columns apply to the criterion, the lower numerical value has to be choosen.

4.9. Risk analysis, risk indices for tailing ponds

4.9.1. Methods of analysis, qualitative and quantitative most commonly used at EU level to assess the risk of industrial accidents

We aknowledge that risk assessment should include identifying, analyzing and controlling of hazards due to the presence of a hazardous substance from an installation (Adler & Mara, 2009).

Definition presented ***(eq.3)*** *by the* Commission Directive 93/67 / EEC, evaluate the following risk assessment distinct components: hazard estimation (including hazard identification, size effects and the likelihood of events) and hazard quantification (including quantifying of the importance of dangers and consequences for individuals and / or affected environment).

We consider that compliance to environmental protection and promoting the range of technologies and products "clean" and new models of production and consumption, together with increasing environmental performance by supporting the implementation of environmental management systems (eg ISO 14000) is a major concern of Member States and is reflected by legislative harmonization of the environmental acquis on industrial pollution control and risk management by initiating and implementing programs to reduce the impact of industrial activities on the environment, along with restoration ecological areas affected.

As a result of our analysis of inventory tailing dams in Romania, in conjunction with hazardous substances inventored on site, we have identified that additional information on the risks of contamination analysed or polluting activities, present at on an industrial site, may lead to the initation of a risk evaluation, in order to determine the probability of a potential damage and affected areas.

We consider that the most apropriate definition for risk is the probability of an adverse effect in a given period of time and is often described by the equation ***(eq 3)*** :

Risk = Hazard x Exposure (Eq. 3)

We consider that in order to apply a general methodology for qualitative risk assessment, should be taken into account the following factors:

(1) Risk / source - refers to specific pollutants which are identified or suspected to exist on a site, their toxicity and their particular effects.

(2) Driving way - is the way that toxic substances reach the point where they can harm, either by direct ingestion or direct contact with skin or by migrating through the soil, air or water.

(3) Target / Receiver - represent the objectives on which acts the harmful effects of certain toxic substances on the site, which may include human beings, animals, plants, water resources and buildings (or their foundations and utilities). These are called in legal terms protected targets.

The degree of risk depends on the nature of the impact receiver and the likelihood of this impact event.

Identification of critical factors influencing the source-path-receiver relationship, requires detailed site characterization both from physical and chemical point of view. Generally, quantitative risk assessment comprises five stages:

- Description of intention;
- Hazard identification;
- Identifying consequences;
- Estimating the range of the consequences;
- Estimating the probability of consequences.

Calculation/risk quantification may be based on a simple system of classification, where the likelihood and severity of an event are classified downwards, randomly assigning them a score:

Simplified model

Classification probability	**/**	**Classification of severity**
3 = high	**/**	**3 = major**
2 = Medium	**/**	**2 = serious**
1 = lower	**/**	**1 = minor**

This risk factor can be calculated by multiplying the probability of gravity, to obtain a comparative figure, such as: **3 (high) x 2 (serious) = 6** . This will allow comparisons between various risks. As much the result is greater, the greater will be the priority given to risk control. This basic technique can be developed to allow more thrusty analyzes by increasing the range of scores for classification and inclusion of more refined definitions of what should be considered to be of major severity, likelihood etc.

Next definitions are taken from the EU Seveso II Directive (96/82 / EC):

Hazard : the intrinsic property of a hazardous substance or a physical situation with potential for dangerous alteration of human health and/or the environment;

Risk : The likelihood of a specific effect associated to hazards that occur in a specific period or in certain conditions that leads to an technological incident / accident.

Hazard was identified with any situation with potential generation of an accident.

Risk is the probability that existing hazard is turning into an accident.

The **risk** in the chemical industry is defined by the likely annual losses or personell accidents as a result of unforeseen technical events ***(Eq. 4).***

$$\mathbf{R = F \times C \ (eq.4)}$$

in which:

R - the risk, losses; (Tons / year)

F - frequency, probability; (No. of events / Year)

C – consequence, gravity, the average loss; (Tons / event)

Possibility of application of the eq. 4, depends on the following factors:

• risk identification,

• determining the frequency of accidents (incidents)

• determination of the average consequences for a particular event.

Identifying risk of accidental pollution is the most difficult, because of the multitude and diversity of related events to the industrial plants, and industrial waste deposits, especially those from mining.

The vulnerability is a fundamental component of risk assessment. In some relationships appears explicitly; in the risk assessment of accidental pollution, the vulnerability is quantified by WRC index (Simion et. al. 2002).

In some analysis, the vulnerability it is considered implicitly, particularly in quantitative approaches regarding technological risk. The combination of vulnerability in the risk management can be made in the analysis of the consequences of an accident. This requires reference landmarks ce (indicators or indices) for use at various levels.

Qualitative analysis has as main objective the establishment of a list of possible hazards, making possible the ranking of the events in order of risk severity and indicate the first step in methodology for quantitative risk analysis. Qualitative estimation of the consequences, is undertaken by classification in five levels of seriousness, a methodology acceptable ate international level and used in risk assessment studies.

We consider that appropriate use of the five levels, which means:

1. **Negligible**, with the following efects for:

- humans (population): insignificant injuries;
- ecosystems: minor efects on few species and some parts of the ecosystem, on short term and reversible;
- sociopolitic: insignificant social effects, wihtout any concerns for the community.

2. **Minor**, with the following efects for:

- humans (population): insignificant injuries;
- ecosystems: insignificant efects on few species and some parts of the ecosystem, on short term and reversible;
- sociopolitic: insignificant social effects, wihtout any concerns for the community.

3. **Major**, with the following efects for:

- humans (population): necessary medical treatment;
- economy: reducing production capacity;
- emissions: emissions inside the plant site, contained with external intervention;
- ecosystems: temporary and reversible damaged, damage to habitats and migration of animal population, plants incapable of surviving, air quality affected by compounds with potential risk for health on long term, potential harm to aquatic life, pollution requiring phisical treatments, limited contaminated soil which can be quickly remedied;
- sociopolitic: social effects, with moderate concerns for the community.

4. **Hazardous**, with the following efects for:

- humans (population): significant injuries;
- economy: intreruption of the production capacity;
- emissions: emissions outside the plant site, withouth harmful effects;
- ecosystems: death of animals, broad-scale injuries, damage on local species and habitat extensive destruction, the air quality requires "safe refuge" or the eviction, soil remediation is possible only through long-term programs;
- sociopolitic: Social effects of serious concern to the community.

5. **Catastrophic**, with the following efects for:

- humans (population): deceased people;
- economy: stopping the production capacity;
- emissions: emissions outside the plant site, withouth toxic effects;
- ecosystems: minor efects on few species and some parts of the ecosystem, on short term and reversible;
- sociopolitic: social effects, with particularly large concern for the community

The measure probability of producing, will be realised, according to our analysis, by classification into five levels (Tab. 23), international accepted and used in different ways, producing the frequency of occurence:

1. **Extremely improbable** (unlikely), could happen just in exceptional conditions lower than 10^{-12} (annual probability appearance in 10^{12} years);

2. **Improbable** could happen sometimes during 10^{-8} and 10^{-12} (during 10^{8} years şi 10^{12} years);

3. **Remote** could happen sometimes during 10^{-6} şi 10^{-8};

4. **Occasional** could happen mostly during 10^{-4} şi 10^{-6};

5. **Extremely certain** could happen in the most cases over 10^{-4} (posibly into a shorter period of time lower than 10.000 years).

The risk level is calculated as the product of the level of gravity (consequence) and the probability of the analysed event.

Extending risk analysis and intensity of the measures for prevention and mitigation must be commensurate with the risk involved. Simple models of hazard identification and qualitative risk not always sufficient and necessary and therefore are used detailed assessments. There are several methods for achieving quantitative pollution risk assessment. The choice of a particular technique is specific to the analyzed accident scenarios. There are further analyzed those accident scenarios, which on the qualitative assessment are considered as potential major, with producing probabilities over 10^{-6}, so can occur often than 10.000 years with major consequences, so an increased risk above level 15 of the risk matrix (table 23). It uses methods of evaluating the accidental emmisions and applied simulation models of the dispersion, based on which is assessed to the seriousness of possible consequences.

Tab. 23. *The matrix for estimating the risk due to industrial pollution (the color codes are similar to those of meteorological and hydrological risks (red is the greatest risk of pollution) adapted to the amount of risk, according to the Directive* 93/67 / EEC *(European Commission JRC, 2003).*

				Consequences				
				Negligible	Minor	Major	Hazardous	Catastrophic
				1	**2**	**3**	**4**	**5**
Probability	Extremely improbable	$<10^{-12}$	**1**	**1**	**2**	**3**	**4**	**5**
	Improbable	10^{-8} la 10^{-12}	**2**	**2**	**4**	**6**	**8**	**10**
	Remote	10^{-6} la 10^{-8}	**3**	**3**	**6**	**9**	**12**	**15**
	Occasional	10^{-4} la 10^{-6}	**4**	**4**	**8**	**12**	**16**	**20**
	Extremely certain	$> 10^{-4}$	**5**	**5**	**10**	**15**	**20**	**25**

4.9.2.1. Measures undertaken by the competent authorities in Romania due to technical accident from Baia Mare

The lessons learned from the detailed analyses of recent accidents at mining tailing dams, for example the last one occurred in Romania, on 2000, at “Aurul” Mine Tailings Recovery Plant near Baia Mare in north-western Romania, are very important for the improving of the safety measures of this type of hydraulic structures (Mara et al, 2006a).

Concerning the safe operation of Aurul or Novat pond-type disposal facilities, Romania’s Ministry of the Environment and Water Management (MEWM) promoted legislation to improve the legal framework for hydrotechnical works that can pose risks for the environment and human beings (NTLH 021, 022, 031-036). This resulted in Joint Orders of the MEWM and Ministry of Public Works and Territorial Planning approving the following methodologies:

- “methodology for categorization of dams”,
- “methodology for assessing the operational safety of reservoirs and dams,” and

- “methodology for assessing the operational safety of dykes associated with industrial waste deposits” (NTLH 2002a).

  A law was issued concerning dam safety, where the term dam refers to all kinds of retaining works, including those carried out for industrial waste disposal. This law imposed regulations that require that safe operation permits for dams and other hydrotechnical works be frequently updated (Government Emergency Ordinance HG 2001). In addition, a government program on safe dam operation has been established, requiring that settling ponds from the mining, power generation, and chemical industry sector by continuously checking and inventoried. In addition, certification of expertise was required at all hydrotechnical works, including mine settling ponds, and specific procedures were established to evaluate potential risks (NTLH 2002b).

  The monitoring system is being modernized by adding automatic stations for the continuous surveillance of water quality parameters. These are located mainly downstream of pollution sources and upstream of the border of the transboundary watercourses. At the same time, a complex program for monitoring water quality, including sediments and biota, was undertaken on the Somes River;
  Guidelines concerning the potential adverse effects of the pollutants on the environment and the intervention procedures for their mitigation have to be completed.

5. Final considerations and proposals for the management of the risk of accidental pollutions caused by tailing dams

We consider that the recent implementation of the newly Seveso II Directive, and afterwards Seveso III Directive which refers to the control of major-accident hazards involving dangerous substances, in different industrial sectors, including mining activities, brings new additional uncertainties, because of insufficient risk evaluation and uncompleted data base at the European level, regarding the risk sources, represented by the tailing dams with dangerous substances. Also the newly implemented Directive on the management of the waste from the extractive industry (DG Env, 2006) didn't clarify the procedural steps for evaluation of the risk against the environment of the mining tailing dam.

The most important advantages given by a new risk weighting identification index, proposed in the paper, will reduce, once applied, the impact on the environment of the mining tailing dams. The presented considerations take into account the conclusions based on the practical experience from Romania. This new approach will improve the tailing dam risk assessment methodologies, in order to eliminate the possibility of technical accidents occurrence as a result of natural hazards (known as NATECH accidents), as in the case of the “Bozanta” tailing dam from Baia Mare in 2000 (Mara et al, 2006b), or the most recent disaster, of the red mud tailing dam from the aluminium industry, from Ajka, Hungary in 2010, also with human fatalities. The newly NATECH failure consequence index being proposed, once applied, will improve the damage assessment in the most unfavourable stability conditions. Moreover, several approaches are taken into consideration, in order to establish an improved standardized methodology of tailing dam evaluation, especially related with the activities of mining processing involving dangerous substances (The Mining Association of Canada, 1994).

In Romania, there is a true need in supporting the local authorities in promoting a sustainable development in environmental factors management and land use development and planning. In this action, a good informational system projection and implementation for natural and consequent technological disasters (NATECH events) are of main importance for local authorities, environmental protection agencies and water management systems. The cartography of risk areas (for damaged areas inventory) will help to organize the local development, to promote projects for local protection of the population and of economical objectives.

5.1. Lessons to be learned: Reducing the risk of NATECH type of accidents at tailings ponds

A realistic evaluation of the risk and a proper management are necessary in order to assure the exploitation and safety operation of the tailing dams from the mining industry, which store dangerous substances (Chamberlain et. al., 1995).).
Romania experiences a wide range of temperatures between warm and cold seasons, with a lower evaporation rate than other countries with similar extractive industries, such as Australia, Spain, and Turkey (Mediterranean Region), that are more arid and therefore do not have the same problems that Romanian operations have with the deposition of the sterile materials in settling ponds.

Proper monitoring systems must be in place to assess structural performance (Jambrik, 1995a), allowing accurate risk analysis and assessment of the operating functions for the tailing disposal facilities for the mining, power generation, and chemical industry sector.

Disseminating lessons learned by analysing past natural disasters to the public and interested parties should constitute an efficient informational method of reducing and preventing several types of hazards. To be effective, measures have to be taken by the local public administration to make such information available, using all the mass media means for communication. Also, based on lessons learned from such disasters, recommendations should be made to the local and regional administration authorities involved in natural disaster management in order to improve preventive measures and better cope with possible failures of technical structures, including tailing dams. Therefore, at the local level, a series of initiatives should be taken to:

- Reduce or prevent disasters caused by extreme meteorological phenomena, such as floods, and accidental pollution;
- Improve speed and accuracy of hazard prediction;
- Improve speed and reliability of emergency response;
- Reduce potential risks and damages;
- Disemintion of lessons to be learned and their results by Internet media for a proper acces;
- Use server/desktop configuration to facilitate coordination between central and regional river basin operations;
- Develop a system to warn potentially affected people;
- Use simulations to assess emergency action plans;
- Develop what-if scenarios and emergency action plans for potential accidental releases from mining or industrial operations;
- Disseminate and communicate accurate, timely, locally relevant, and reliable assessments of risk.

For a better assimilation in practice the lessons learned from previous significant NATECH disaster at tailing dams, the involved authorities should be able to:

- Provide information to the population concerning the level of risk near their inhabited areas, including measures that have been taken to minimise risk. Information must be disclosed at the local or regional level in order to allow the public to access information regarding the relative risk of natural or technical accidents (NATECH) in various areas, thereby allowing the local population to avoid living in areas that are more prone to hazards;
- Develop, at the request of stakeholders and companies, a detailed analysis of the potential consequences and damage distances for possible scenarios of NATECH accidents involving potentially dangerous installations and sites storing highly toxic compounds;
- Define a set of potential accidents and related consequences that could happen at the selected facilities, given various NATECH events. Information gathered on population and the environment should allow potential consequences to be defined for every environmental component;
- Develop a complete perceived risk report for the inhabited centres around industrial sites that are considered potentially vulnerable to NATECH accidents, extending the implementation and integrating the process with other EU and Candidate countries to provide an overall common view of the risk for NATECH;

▪ Be able to participate in the extension of this NATECH risk evaluation methodology to include more detailed analysis of other risks associated with the mining industry. Europe needs to support the local authorities in promoting sustainable development, factoring in current and prospective land use and disaster management;

- Inform the public, including tourist resorts, regarding the possible consequences associated with natural hazards specific to the region and implementation of the results of the APPEL program for mining (EnvSec, 2005). This should result in a more precautionary behaviour of the local population and tourists, and limit the consequences in case of a natural disaster, including NATECH. This should involve the use of all available means, including warning panels, posters, and leaflets, in resort areas that are highly vulnerable to natural disasters, advising people to be aware of and avoid the dangerous areas, since natural and NATECH disasters frequently affect inhabited areas, and endanger the environment and infrastructure, due to vicinity of the vulnerable industrial sites;

- Develop and maintain a good information system on the risks of natural and technological disasters and provide access to local authorities, environmental protection agencies, and water management systems. The EU's Natural and Environmental Disaster Information Exchange System (NEDIES) data base of lessons learned should help improve disaster management activity in EU and candidate countries (Jordan & D'Alessandro, 2004).

- An increased control of the mining activities under the requirements of the Seveso II Directive, in order to impose to the exploitation companies, which intend to activate in Romania, the necessity to implement the design technologies of the tailing pond, according to the safety norms of the Romanian legislation, because great variation of the climate and consequently, of the hidrological conditions (Romania has a continental type of climate characterised by a wide range of temperatures between warm and cold seasons, with a lower evaporation rate than other countries with similar extractive industries, such as Australia, Spain, and Turkey (Mediterranean Region), that are more arid and low air humidity, and therefore do not have the same serious problems that Romanian operations have with the deposition of the sterile materials in settling ponds, by classic hydrotransportation system.

- The Romanian regulations for the issuing of safe operation permits for dams and other hydrotechnical works should be updated, according with the requirements of the Seveso II Directive, and afterwards Seveso III Directive, including assuring, through certification, that there is adequate expertise to assess and operate hydrotechnical works that can pose risks for the environment and human beings.

- An intensive programm of experts attestation in order to perform expertize at hydrotechnical works including tailing dams for the mining industry;

- A technical expertise of dam safety operation should be regularly reviewed for the tailing dams from mining, thermoelectric power sector, and chemistry (Mara et al, 2010), by hidrographical basins (***Fig 36***).

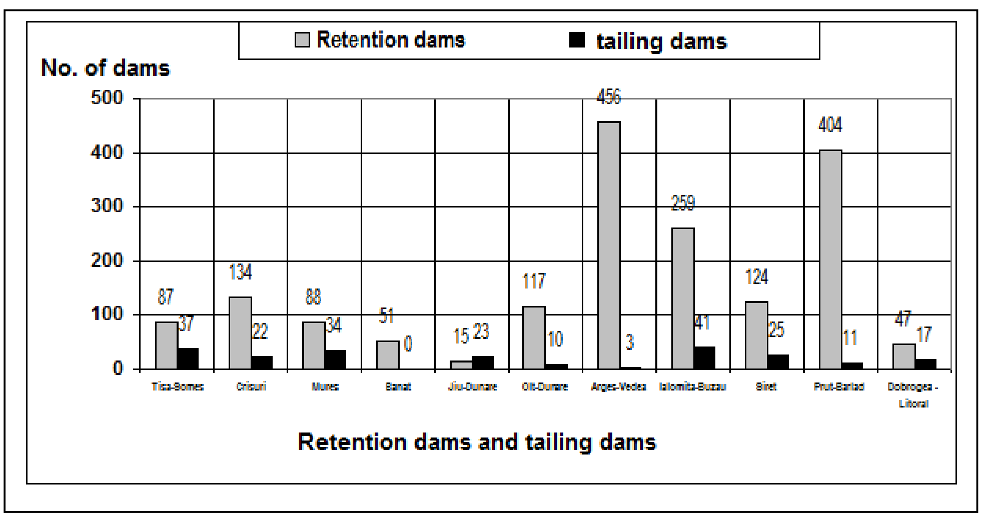

Fig.36. Inventory of the tailing dams from Romania by hydrographical basins

In addition, new indicators for evaluating the quality of the environment relative to potentially dangerous substances should be implemented. For example, the health of stream biota, especially endangered species, can be used to gauge the extent of pollution, especially for transboundary cases.

The means of transporting the waste material and, where appropriate, the dam construction methodology, should be updated to increase the safety of the settling ponds, in order to completely eliminate a possible technical accident with uncountable damages.

By way of example, since 2002, through an EU communitarian funded project, the ash at the SE Timisoara/CET South thermoelectric power plant is now transported and deposited as a relatively dense fluid allowing higher contour dams and increasing the height of the ash deposit. This system use low water quantities (or other liquids), so that in less than 24 hours, the detritus reaches the consistency of concrete, allowing one to walk on the settling pond without any risk. In this way, the water and mud is completely eliminated from the settling pond structure, and there is no return of waste water or any other liquids back from the settling pond (Tiwary & Dhar, 1994).

Following the Baia Mare NATECH accident, Romania is improving communication between the public administration and the authorities involved in the management of natural disasters on one side with the public and experts from different sectors of the society involved in land planning, to better allocate the resources necessary for hazard reduction and mitigation activity. The lessons learned from disasters that have recently occurred in Europe will lead to improved management of natural hazards within EU and candidates countries (CE, 2000), and will reveal the existent inherent gaps in mitigation activity (EnvSec, 2005).

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