Integrated quality environmental monitoring and warning-alarming system for emergencies due to technical accidents at waste deposits in mining industry

S. Mara[1], S.N. Vlad[2]

[1]*Ministry of Environment and Forests, Bld. Libertatii no. 12, sect. 5, Bucharest, Romania, maraseptimius@yahoo.com*
[2]*Faculty of Environmental Sciences, – Ecological University, Str. Franceza no. 20, Bucharest, Romania, serban.vlad@caronet.ro*

Abstract A suitable mining monitoring coupled with a warning-alarming system for mining areas should meet the initiatives of the competent authorities in the field of environmental protection. This measure is to improve the communication between the public administration and local authorities involved in the management of the technical accidents on one side, and for a better allocation of the necessary resources for diminishing the natural hazard effects and the activity of the emergency situations generated, on the other side. The paper presents an integrated topic of a wide variety of issues regarding the environmental protection strategy. Its scope is to promote the implementation at national scale of an integrated decisional system for controlling the impact of mining activities on the environment, especially the aquatic one.

Key Words environmental monitoring, warning-alarming system, technical accidents, dangerous waste deposits, BAT's

Introduction

The quantification of risk associated with tailings and industrial waste deposits requires the use of a unified system of categorisation, for better correlation of the characteristics of varied sites and their potential hazards. Managing such risks requires that the obligations of tailing dam owners and operators be defined so that they can be operated safely and adequate measures can be taken to reduce the risks of accident (Mara et al. 2007). The nature of required controls vary, based on the degree of potential risk and their potential environmental impact, especially for surface waters, as in the case of Baia Mare technical accident (occurred on 30 January 2000 at around 10 p.m., when a tailing dam broke at the Aurul Mine Tailings Recovery Plant near Baia Mare in northwestern Romania, (due to liquid precipitation fallen on a thick snow layer). Approximately 100,000 m^3 of a high cyanide and heavy metal spill discharged into the receiving creeks, and from there onwards into the river network of the Danube Basin (Somes/Szamos; Tisza and the Danube). In the same mining region, another tailing dam broke at Baia Borsa on 10 March 2000, due to a severe rainfall, spilling 40,000 tones of heavy metals sediments. These two serious accidents with a trans-boundary impact initiated a rapid response within both the ICPDR and the EU. The Romanian Principal International Alert Centre announced in due time the population and the trans-boundary countries in order to take the necessary measures for preventing any contamination, being noticed that not any affected persons were recorded.

Therefore the monitoring system of the environmental factors should be modernized, especially by adding automatic stations for the continuous surveillance of water quality parameters. These have to be located mainly downstream of pollution sources and upstream of the border of the trans-boundary watercourses.

Methods

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).

The quality of monitoring data is also a critical factor for assurance of the investment decisions, therefore the frequency of sampling have to be established in an optimal way.

The water quality sampling in the monitoring sections should be performed at a frequency which allows a sufficient precision to the results in order to be drafted appropriate measures regarding the improvement of the water quality status of the stream, downstream of the potentially pollution sources, represented by the tailing mining dams, including reduction or the elimination of some pollutants.

These measures can establish new quality limits for the waste water discharges from the mining sites activities, or restrictive measures related to the discharged volumes. These decisions could have important economical consequences, being based by the sampling and precision control of the analyzed sampled results. The number of the samples for reaching a certain precision at a specific certitude level with a known standard deviation it the following:

$$n = (us/d)^2$$

where:

n is the number of samplings for a certain precision;
u the normal deviation corresponding the requested trust level (for ex. 1.65 for 90% trust);
s standard deviation (mg/L);
d necessary precision (for ex. 0.1 mg/L).

Nowadays the economical conditions requests annual minimal operational costs for the monitoring system, such as indirect costs laboratory analysis, in order to don't exceed the planned costs. Therefore, one of the most economical method for a continuous in situ evaluation of the water quality status is based on the Dissolved oxygen contents (O_2), and the the water quality analysed in the monitoring stations can be assessed according to 5 quality classes of the classification system (table 1).

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. Taking into account the most relevant mining pollution sources and the related pollutants, two main decisions should be taken into account in case of an accidental pollution dected by a monitoring system, depending the assesed impact, as it follows:

i acute (eco) toxicity for the quatic ecosistems and adverse effects on the human health, in the most critical situation, are taken adequate prventive measures (for example shut down of the water intakes), or the in situ decotamination of the stream;
ii cronical toxicity based on the bioacumulation of the specific pollutants in biota (for example heavy metals, especially Hg, Cd, Pb, Cr, etc), resulting in water use limitation.

Table 1 *Dissolved oxygen used as a main parameter for identifying the pollutions in the cross section of the monitoring system*

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

State of the 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.

ANAR and its 11 territorial Water Directorates supervise the qualitative and quantitative status of water resources through the National Integrated Water Monitoring System, which includes 1080 monitoring stations and 3549 wells, covering 78,905 km of water courses, groundwater, Danube Delta, and the Black Sea Coastal waters. The water monitoring is conducted through 41 ANAR laboratories, specialized in running physico-chemical and biological analyses. A part of these stations provides the trans-boundary informational system in the Danube River Basin, Black Sea catchments and at the European level (EUROWATERNET network).

Baia Mare technical accident occurred in 2000 on Somes river hydrographical basin (Fig. 1), the most impacted mining field in terms of potential pollution risk sources (Mara et al. 2006). Accordingly a complex monitoring program for water quality monitoring including sediments and biota was conducted.

So far several methodologies have been elaborated/adapted by ANAR in order to improve the framework activity of water quality control: defining the a-biotic typology of streams, delineation of surface water bodies – rivers and lake preliminary identification of artificial and heavily modified water bodies – rivers and lakes development of the integrated water monitoring national system, identification of the pollution spot and diffuse sources, assessment of their impact on surface water and cost recovery in the water field at the river basin scale.

Trans-boundary water quality status monitoring

Water quality of the watercourses in the Hungarian-Romanian border region showed a generally improving tendency since 1993. The evaluation of the trans-boundary water quality trend was

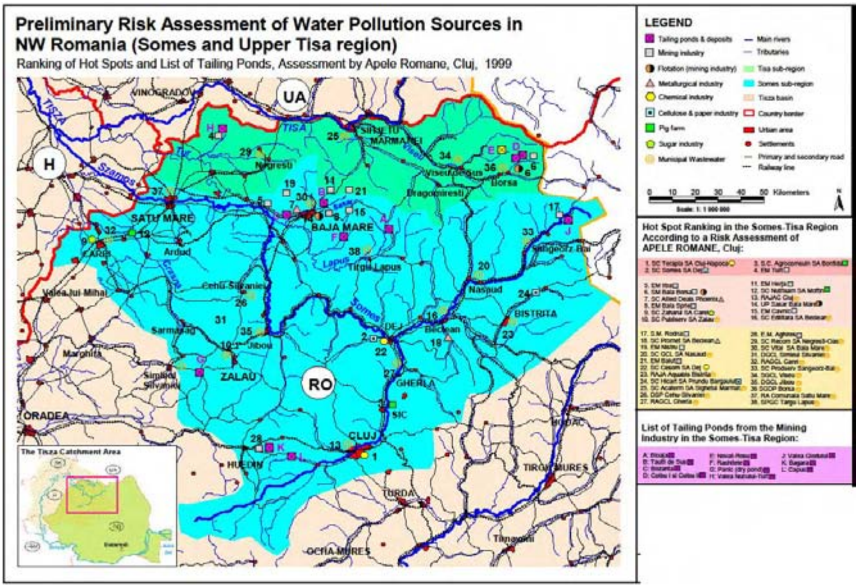

Figure 1 *Preliminary risk assessment of water pollution sources in NW Romania (Somes and Upper Tisa areas)*

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.

Data used in analyses and evaluation are the results of the joint examinations performed by the bordering 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.

Generally speaking the main potential pollution sources of the surface waters are represented by the local comunities, chemical industry, followed by the mining industry and metalurgy; in case of accidental pollution, the mining industry contribution might prevail.

Conclusions

The feasibility studies show 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. Enhanced water quality manangement involving also the water users and the pottential polluters, is based on effective measures undertaken for waters disaster prevention and mitigation, especially by modeling the contamination propagation.

Besides improving the monitoring system capability of the mining sites in order to avoid further accidental pollutions, the mining companies have to take also precautionary measures at the level of industrial facilities as following:

- The monitoring activity should take into consideration pollutions events neglected so far, including values of water pollutant below the maximum admissible values, because of the bioaccumulation effects of the toxic substances, especially for heavy metals. River quality modelling for larger streams should be different compared with the one used for smaller rivers.
- Endowment with propagation models for inner rivers for a rapid evaluation of the concentration plume in surface waters, to establish the necessary measures for pollution control (assurance of a dilution below the alert thresholds, controlled sampling knowing when the pollutant maximum concentration reach the control section, reducing the cost of the monitoring activity, etc.).
- Existence 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 at the storage and the registered quantities.

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