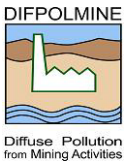

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FINAL REPORT

Description of the adaptation potential of the ”Difpolmine” approach, modifications and evaluation of the adaptation to the Hungarian site

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Introduction

To demonstrate the adaptation potential of the Difpolmine approach, the Toka valley site has been selected in Hungary. The former Zn-Pb mine differs in many aspects from the Salsigne site, but the main concept of GIS modelling and combined chemical+phytoremediation was expected to be applicable.

After the identification of the main differences the "methodology" was adapted to the Toka-valley site. This complete Hungarian methodology contains also the stages prior to the treatment of the diffuse pollution: mine closure, differentiation between point and diffuse sources and risk reduction of the point sources according to their actual and targeted risk value.

The catchment scale GIS based risk model of the Toka valley site was worked out on the basis of the dominant risk and main pollutant transport pathways, which is the runoff and the surface water system, therefore the most exposed receptors are the members of the water-ecosystem.

The risk reduction concept is based on the reduction of the quantity and improving the quality of the runoff water by removal of the point sources and chemical+phytostabilisation of the residual and diffuse pollution. The only water which needs direct treatment is the mine water: this will be treated by liming or by alternative mine-water treatment technologies, like passive treatment using Reducing and Alkalinity producing System (RAPS).

Hungarian context at the beginning of the Project

Gyöngyösoroszi is a village along the Toka-valley, North-East from Budapest, near to the town of Gyöngyös, close to the Mátra Natural Park (Mátra Mountains) in Hungary, where operation of the former Pb, Zn underground mine including relevant infrastructure, flotation plant and tailings dam ceased 20 years ago. At the start of the Difpolmine Project in 2002, the mine has not been officially closed, although it has been suspended for 15 years. The complete remediation of the polluted area has not even been planned at that time.

The mining operation included the following facilities: acidic mine water treatment plant at the main mine entrance and the sedimentation ponds/reservoirs associated with it, the flotation plant, the ore transportation route from the mine entrance to the flotation plant, the tailings dam, the industrial reservoir which supplied water to the flotation plant, various historical mine workings the reminisces (mine waste dumps) of which are to be found dispersed in the forest North to the mine entrance. The acidic-mine drainage running out continuously via the main mine entrance is continuously limed and the lime-precipitate is settled and dumped in open reservoirs. The treated mine drainage gives the main volume of the central surface water flow of the Toka creek.

Springs, temporary water flows and runoff waters create the surface water system upstream the main mine entrance and downstream the mine they join the treated mine water. Before the establishment of the neutralisation plant (in 1985), the acid mine drainage flew directly into the surface water system (downstream the main mine entrance), where it was *in situ* neutralised. This lime precipitate is up to now part of the sediment, which is transported both by irrigation and floods to the soil of the surrounding agricultural land and hobby gardens.

The owner of the former mine is the Hungarian Privatisation and State Holding Company (ÁPV Co.), which is the main proprietor of the entrepreneurial assets of the Hungarian State. The ÁPV Co.'s task is the sale and market based management of state assets determined by law as well as rendering accounts and the controlling of earlier privatisation transactions.

Therefore, the APV. Co. is responsible for the Gyöngyösoroszi mine ground, the water neutralising plant and all dumps, ponds and reservoirs belonging to the mine. The former flotation plant has been sold to a small size enterprise. The tailings material still belongs to the APV Co. The secondary polluted areas, like surface water system and the soils of the surrounding areas belong to different governmental and private owners.

The Toka valley has been the subject of many studies done by BME starting with 1991, especially following the major floods that occurred in the area in 1991 and 1996 (Bekő, 1992;. Gruiz and Vodicska, 1992; Gruiz, 1994; Horváth, 1996; Horváth, 1997)

Many university training courses and an International Training Course **Euro EcoRisk II** on **„**Environmental Risk Management on the Gyöngyösoroszi Mining Site" was organised by BME in 1996.

Further surveys done by BME on the pollution of the area resulted diploma and Ph.D. theses and a series of publications. After a while the pollution problems of the area raised public interest.

In 1996 the Toka creek area in Gyöngyösoroszi was included into the National Priority List of the National Environmental Remediation Programme.

The Hungarian Privatisation and State Holding Company (ÁPV Co.) passed a decision in 2003 in reference to the complete mine closure and remediation of the Gyöngyösoroszi mine area in the frame of the Hungarian Environmental Remediation Programme of the Ministry of Environment and Waters.

The complex solution will focus on mine closure, remediation of point sources, like the lime precipitate, the tailings material, mine wastes, contaminated sediments and soils including the remediation of diffuse and residual pollution.

In this context the aim of the work in the Difpolmine project was to evaluate the site and the results of former surveys, to characterise the pollution transport and the environmental (both ecological and human health) risk, to understand the inner structure of site specific risk in order to design the most effective risk reduction by complex risk management including both pollution control and remediation. In order to adapt the Salsigne methodology we had to select a suitable sub-site, to identify and characterise the concentrated and diffuse pollution sources, to get information on government's concept and remedial plans and harmonise the DIFPOLMINE concept with the planned site remediation. The historical and new data were included in a GIS based model, a 3 step **risk assessment** was applied to the highest risk area, the Northern sub-site. The results of risk assessment served as starting point for the design of risk reduction measures.

According to the adapted approach the first step of the **risk reduction** measures in the Toka-valley is focused on reduction of the risk of the point sources. This will actually take place in connection with the final closure of the mine and the complete remediation of the site. Further risk reduction can be reached by a second step, decreasing the emission and transport from the diffuse sources. A third, complementary step includes some adequate changes in the land uses. The three together would provide a final solution for the site to reach an acceptable risk level.

Description of the Hungarian demonstration site

Gyöngyösoroszi, the Hungarian demonstration site is a former Zn-Pb mining area, situated in the Toka-valley, 90 km North-East from Budapest, near to the town of Gyöngyös, in the vicinity of the Natural Park of the Mátra mountains.

Figure 1. Location of Gyöngyösoroszi

Historical mining for gold started in the area already in the Middle Ages and the underground mining of the lead and zinc bearing vein type mineralisation intensified during the last century and was suspended in 1986. The mined base metal ore was milled and processed in the local flotation plant. The flotation tailings were discharged into a tailings dam from 1955. The acid mine water exiting via the main adit was treated and is being treated by lime from 1985, the sludge is settled in 3 storage ponds and the treated water is discharged into the Toka river.

Final closure of the mine and remediation of the site has not been carried out yet.

For the purpose of the work the Toka catchment area was divided in three zones based on topographical, meteorological and environmental characteristics and the type of pollution and land uses.

The Toka catchment area covers 25 km^2 starting from the emerging springs area down to the inflow into the Gyöngyösi lake (altitude 150 m).

The Northern catchment ("water zone") of the Toka creek extends on 10 km^2 (from altitude 450 m to altitude 750 m) (starting from the emerging springs area down to the Flotation Tailings Dam).

The middle section of the Toka river course was denominated the "sediment zone", because the sediment is the main polluting environmental element. This area covers the river section starting from the upstream end of the village to the downstream end of the village.

The lower section of the Toka creek course was denominated by us the "soil zone". It covers the hobby garden area and starts from the downstream end of the village to the inflow into the Gyöngyösi lake.

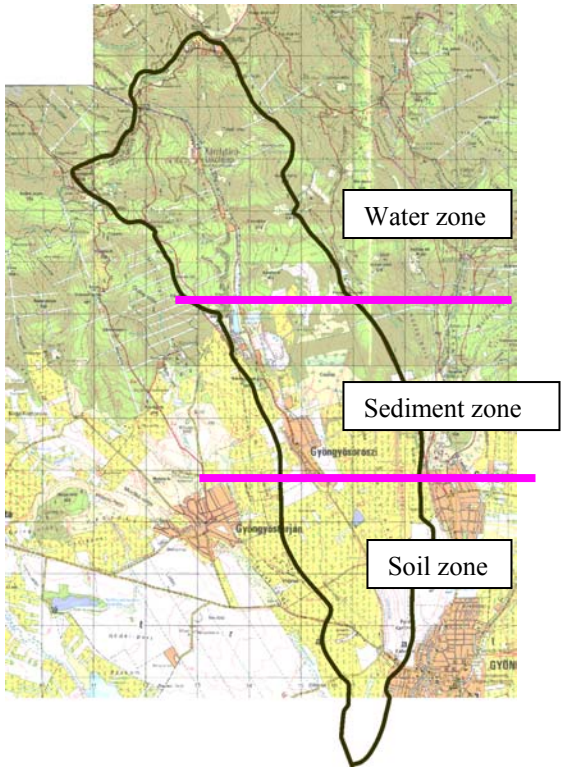

Figure 2. The Toka catchment area

The relatively small catchment is very much diversified: the Northern part is a typical mountain area with relatively low temperatures and a lot of precipitation. There are springs and temporary water flows in this area. The topography of the Northern border is typically steep. The height of the

mountains along the Northern limit is 800–820 m (Baltic Sea). The Northern border is limited by the area of Bagolyírtás in NE and further to the North by the locality of Mátraszentimre and NW by the locality of Mátrakeresztes.

The village of Gyöngyösoroszi is situated at the foot of the mountain.

Downstream the village the topography becomes mostly typical for plains.

This is the hobby garden area that continues along a narrow line down to the inflow of the creek into the Gyöngyös lake. The riverbed in the lower part is deeper and narrower. Gyöngyösoroszi and Gyöngyös residents' hobby gardens are often flooded by the Toka creek.

The pollution sources in the area are of several categories: underground mine wastes, flotation tailings and lime precipitate from mine-water treatment. The secondary sources are: sediments of reservoirs (originating from flotation tailings, lime precipitate, eroded rocks and ores), and contaminated soil.

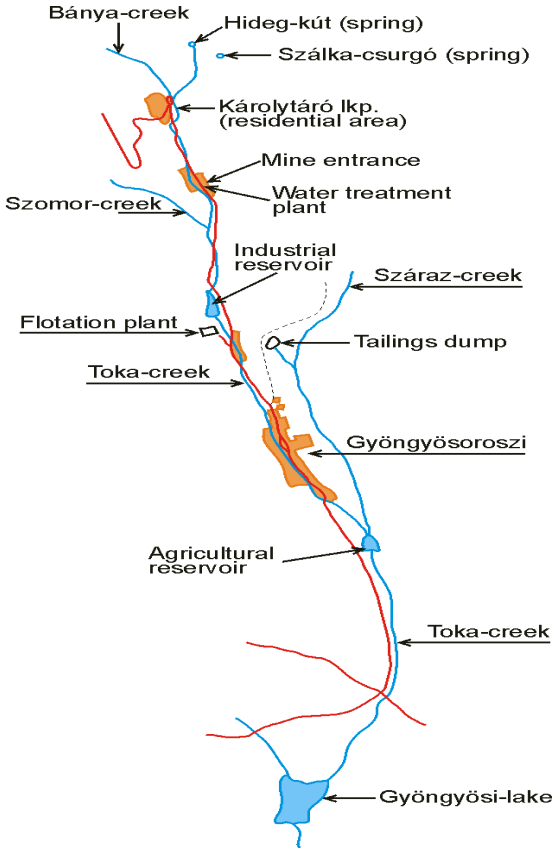

Figure.3. The sketch of the Toka creek

The treated mine-outflow joins the fluctuating amount of surface water flow. The acid-mine drainage is continuously limed and the lime-precipitate is settled and dumped in open reservoirs. The treated mine water gives about the 50 % of the flow rate of the Toka creek. Before the establishment of the neutralisation plant (NP) in 1985, the mine outflow got directly into the surface water system (downstream the mine entrance), where it was *in situ* neutralised. This lime precipitate was incorporated into the sediment and transported both by irrigation and floods to the soil of the surrounding agricultural land and hobby gardens. Table 1 shows the toxic metal concentrations of the Toka creek upstream the discharge from the mine water treatment facility, measured at various times.

Table 1. Toxic metal content and pH of the Toka creek water

Location Year Metal	MU	**EQC-HU (subsurface water!)**	Upper Toka creek 2004	Toka creek: Southern border of the water zone				
				1991	1992	2004	2005	Weighted average
As	µg/lit	25	2.9	10	nd	2–112	7–50	**50**
Cd	µg/lit	5	0.5	30–50	5–16	1–5	0.5–4	**2**
Cu	µg/lit	200	50.0	20–40	nd	3–90	nd	–
Pb	µg/lit	10	28.0	30	6–55	1–120	4–105	**30**
Zn	µg/lit	200	1 620	9000–14 000	500–6000	100–1600	300–1650	**800**
pH	–		4.4	2.0–5.0	2.6–5.0	5.0	5.0	

Table 2. shows the metal content of the regularly flooded garden soil. A clear decreasing gradient can be measured with the growing distance. This fact serves as evidence on the origin of the pollution: Toka creek sediment transported by floods.

Table 2. Metal content of the flooded hobby garden soil (Gruiz and Vodicska, 1992)

Soil	Distance from Toka	As mg/kg	Cd mg/kg	Cu mg/kg	Pb mg/kg	Zn mg/kg
Hobby garden	5 m	110	7.5	210	462	1685
Hobby garden	15 m	63	1.0	127	248	998
Hobby garden	30 m	31	0.6	200	120	520
Hobby garden	50 m	–	0.6	131	63	208

For the purposes of the DIFPOLMINE project the Northern catchment of the Toka river as the main pollution source called "water zone" has been selected for further assessment, risk mapping and for the adaptation of the Salsigne risk management system.

The water zone covers 10 km^2 from altitude 450 m to altitude 750 m. The average slope in the Northern catchment is 13%, the maximum slope is 43% and the average slope for the total Toka catchment area is 11%.

The Northern catchment is located in an area with andesite rocks of Miocene age hosting vein-type base metal sulphide mineralisation overlain by Tertiary formations. Hydro-geologically, it is characterised mainly by cracks, faults in the andesite rock formations resulting high infiltration rates. The permeability of the clayee tertiary formation is medium. The creeks in the area have water only seasonally (heavy rainfall events, melting of snow). The underground water level in the area of the Gyöngyösoroszi village is at 2.2-2.4 m depth and further to the North in the mining area it is located at 9.0-9.2 m depth, having a flow direction from North to South following the morphology of the surface topography.

The following toxic metals cause the pollution: Cd, Zn, Cu, Pb, As. The Cd and Zn exist mainly in dissolved/ionic form contaminating surface waters and leachates, while Pb and As are dominantly bound to solid phase elements, like soil and sediment. The Gyöngyösoroszi site is sensitive to the pH, because of the sulphide-content of the rock and the dominant biological acidification.

Components of the adapted Difpolmine methodology applied to the Toka valley

A complex environmental risk management methodology was developed for the Gyöngyösoroszi former lead-zinc mine area in Hungary, as shown in Figure 4. To apply the Difpolmine concept, a complex multidisciplinary methodology is required. The methodology shown in Figure 4. has three main category components: type of **action,** subdivided in 9 subcomponents (1.1, 2.1, 3.1, 4.1, 5.1, 6.1, 7.1, 8.1, 9.1), developed **tools** relevant to individual activities, subdivided in 7 subcomponents (1.2, 2.2, 3.2, 4.2, 5.2, 6.2, 7.2) and the **outcome** or **result** of the relevant actions and tools, subdivided in 9 subcomponents (1.3, 2.3, 3.3, 4.3, 4.3.1, 4.3.2, 4.3.3, 5.3, 6.3). The subcomponents of the completed **actions** with the applied tools and their results are detailed in this chapter:

Types of actions

1.1 Creating the conceptual model of the site and identification of the pollution transport pathways based on which the Water Balance was created
2.1 GIS based Flow and Pollution transport modelling
3.1 Collection and evaluation of historical and measured data
- Hydrogeological data collection
- Delineation and mapping of waste dumps
- Chemical, biological analyses of the contaminated environmental elements
- *In situ* chemical analyses XRF
- Laboratory analyses of environmental samples: physico-chemical characteristics and metal content
- Biological testing of toxicity

4.1 Microcosm modelling of processes to obtain model-parameters
- Bioleaching
- Immobilisation/stabilisation of contaminants in soil

5.1 Qualitative site specific Risk Assessment methodologies for ranking
6.1 Quantitative site specific Risk Assessment methodologies for quantification of the risk of the individual sources and the total site and for the calculation of target risk
7.1 Selection of the remediation methodology based on laboratory and field experiments
8.1 Cost evaluation by cost efficiency and cost-benefit assessment
9.1 Validation

1.1 **The pollution transport pathways** were identified taking into account the site-specific parameters of the area and the actual status in terms of mine closure and complete remediation planning.

The Gyöngyösoroszi mine ceased its operation in 1985, however the mine closure is being planned only now. All point pollution sources are still in place and the remediation alternatives are being evaluated.

The site specific parameters include: hydrogeology, geology, topography, pollution sources, ore type, intensive bioleaching, toxic metals, surface water system, meteorological condition.

The hydrogeology is determined mainly by the cracks and faults in the andesite rock formations. The waterflows in the area are typical for the Mátra Mountains, small creeks, valleys formed along fault lines and the water flowing in them is only seasonal. The water is delivered into the creeks by streams. The streams

stem from the bottom or sides of the riverbed. On certain sections the creeks disappear and then reappear again. The highest water volume is to be found after heavy rainfall events or in springtime when the snow melts. Usually in summer the bed of these creeks is dry. The mining operations contributed to an increase of the infiltration rate in the area. A small part of the infiltrated precipitation gets through the mining works into the mine and flows out on the main gallery (Altáró, 2000 m^3/day). The surface pollution does not reach the underground water level by means of the infiltrated rainwater. The toxic metals get fully bound already in the upper few 30–50 centimetres of the clayey debris like material, given that the conductivity of this type of material is not high and the pollutants could migrate only exclusively by diffusion and the toxic metals get adsorbed on the surface of the clay particles. However the pollutant retention capacity of the andesite is highly limited.

The pollution sources are of several categories: mine waste of underground origin, flotation tailings and wastes from the acidic mine- water treatment. Due to the long-term distribution/dispersion of the wastes on the site also secondary sources have been formed, like sediments of reservoirs (originating from flotation tailings, lime precipitate, eroded rocks and ores), and contaminated soil (resulted by floods and the deposition of contaminated sediments).

2.1 **GIS modelling**: the GIS database for GIS mapping was put together from the available and acquired information about the site. The GIS database of the studied area has been built up using digital data acquired from the Hungarian Institute of Geodesy, Cartography and Remote Sensing (digitised contour lines from the National Topographical map 1:10000, Corine land cover data set obtained from the Hungarian Institute of Geodesy, Cartography and Remote Sensing, National Topographical map scale 1:10000-scanned copies of the paper maps, resolution 0,85m) and input data from field mapping. The database provided information/data for the basic engineering of the methodology and substantiated the modifications in the implementation of the methodology.

The GIS work included the following steps: construction of the DTM_TIN from the digitised contour lines. The DTM (Digital Terrain Model) was built using ArcView3.1 3D Analyst. The DTM_GRID derived from the DTM_TIN, resolution 10m. The sinks were removed from the DTM to get unbiased result from Hydrologic analysis.

The following layers derived from the DTM GRID:

- slopes which are tilt angle of the topographical surface
- azimuth of the slope
- flow direction grids (flow dirs), where each cell shows the direction of the water flow. The eight possible directions were bit-coded. The accumulated flow is based on the flow dirs grid, which considers the upslope cells. The temporary and permanent water flows were visualised based on the flow accumulation.

3.1 **Collection and evaluation of historical and measured data:** an inventory of data originated from historical mining database, previous studies, on site measurements performed by BME in the Gyöngyösoroszi area have been put together and evaluated.

The main component of the work for development and application of the methodology was field work focussing on mapping of waterflows (permanent, seasonal, surface and subsurface runoff waters), waste dumps, soil, transported sediment, delineation of the waste dump area and of the contaminated soil area. Works undertaken during mapping of the waterflows included: GPS location, estimation of the flowrate, transport capacity, in situ measurements, on site observation.

The daily rain gauge data, the daily water flowrate in the Toka creek in correlation with the historical meteorological data enabled us to distinguish regular, medium and extreme rainfall events and calculate the produced runoff percentage in the Water Balance for every individual case.

The mine waste dumps were delineated and mapped on site. Where possible their surface area was measured, the extent of contamination of every individual dump was delineated by the portable NITON XRF device. The contamination level was estimated also by laboratory analysis of the contaminated environmental elements. The phase of bioleaching (pH dependent) and percolation was assessed.

4.1 **Microcosm modelling of processes to obtain model-parameters**

- A *microcosm* bioleaching test has been conducted to model the environment within a mine waste dump and its surrounding area, to quantify the amount of metals emitted from the dump during an average yearly rain event (Szabó, 2003; Gruiz et al., 2006). The amount of metals deriving from the waste rock was calculated from the results of the leaching test.
- Immobilisation/stabilisation of contaminants in soil was modelled in microcosms to determine the most efficient amendments/immobilising agents like fly ash, iron oxide, lime, lignite to be added to the soil and the plant species able to grow on the substrate were selected (Feigl, 2005).

5.1 **Qualitative site specific Risk Assessment methodologies for ranking**. Preliminary Qualitative Risk was assessed based on a site and problem specific questionnaire, resulting a score (point numbers) enabling ranking of the pollution sources. The qualitative risk assessment provides a relative list of pollution sources, therefore the size of the real risk cannot be assessed from it, but only the relative order of the pollution sources. The point system takes into account source quality and quantity, transport pathways, land use specific receptors.

6.1. a **Quantitative Hazard Assessment:** The Quantitative Hazard Assessment allowed for determining the risk of each pollution source. The direct precipitation (direct runoff) and the indirect water flow (run-through) were first determined. Then, the metal amount transported by the runoff water was calculated on the basis of the leaching test. The calculated emitted metal amount was used as quantitative parameter to characterise the hazard of the individual sources, sub-areas and total area.

6.1. b **Quantitative site-specific Risk Assessment methodologies for calculation of the target risk**. According to the site specific Quantitative Risk Assessment of the Toka catchment area the risk quotient (RQ=PEC/PNEC) is higher than 1 (RQ>1). The target risk value is RQ =1. The PEC is given by the measured metal concentrations of the Toka creek water and sediment. The PNEC is defined based on effect based quality criteria obtained from literature and regulatory data. The aim is to reduce PEC to the PNEC value. The Natural Risk Reduction Efficiency ($NRRE_{min}$) of the soil was calculated using the minimum emission from the sources and the actually measured values in the surface water (Toka creek). The target emission from the sources to achieve the target concentration in the surface water (EBQC) is calculated in case only the $NRRC_{min}$ of the site works. The expected target Risk Reduction Efficiency (TRRE) to reach the previously set target emission from the sources is also calculated. Comparing the expected TRRE efficiency and the efficiency of chemical stabilisation, the expected efficiency of phytostabilisation is obtained.

7.1 **Selection of the remediation technology**. Several alternatives were considered to select the most efficient one: a) no remediation, however monitoring is needed, b) only phytoremediation, c) combined chemical and phytostabilisation, d) two versions of removal and replacement of the polluted material with unpolluted borrow material. Selection of the target value oriented remediation option was based on the predicted concentration of the outflow from the catchment calculated by the GIS based Pollution Transfer Model.

8.1 **Cost evaluation by cost efficiency assessment**. A comparison between the costs of the selected remediation alternatives considered for the Gyöngyösoroszi site has been done to substantiate cost efficiency of the chemical and phytoremediation option. The cost calculations were done based on the results of the chemical stabilisation tests and included a technology planning for 7 years of treatment.

9.1 **Validation.** The data used for the application of the GIS based Pollution Transfer Model were validated by model parameters and reverse calculations. After the application of the combined chemical and phytostabilisation the calculated data will be controlled by field measurements and monitoring.

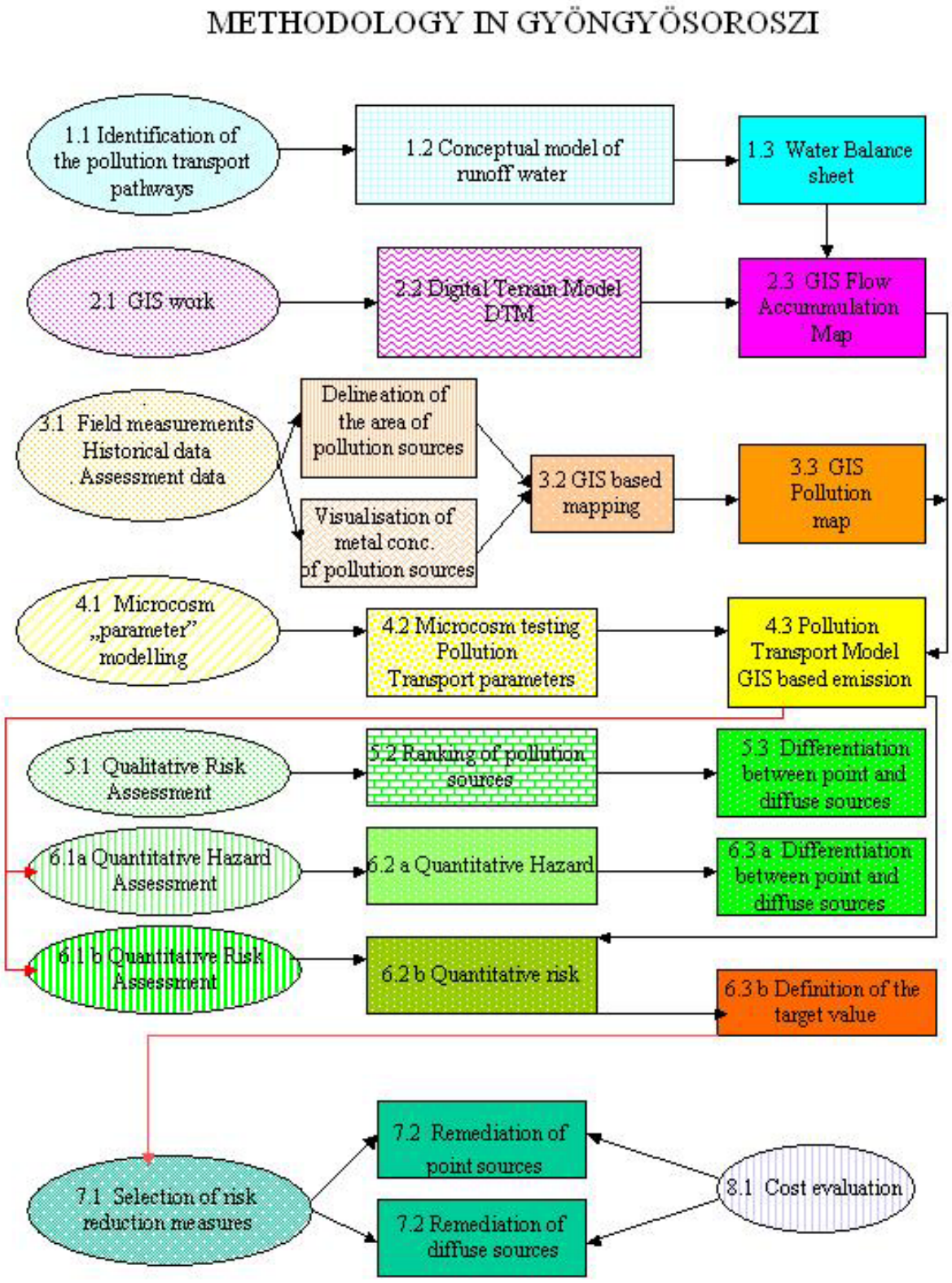

Figure 4. Scheme of the integrated risk-based management system

Figure 5. shows the scheme of the Risk based Transport Model for the calculation of the remediation target value

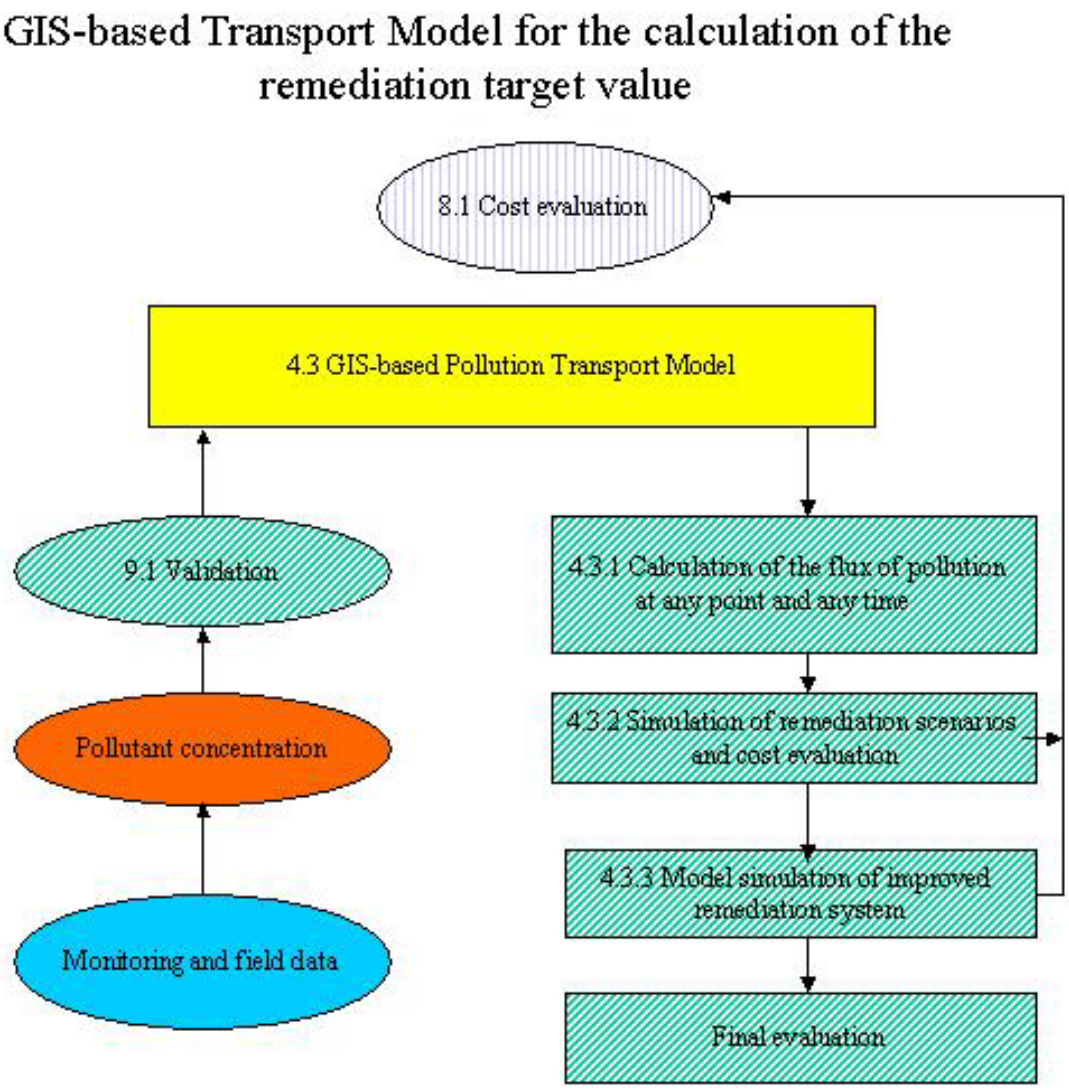

Figure 5. Scheme of the Risk based Transport Model for the calculation of the required reduced emission from point and diffuse sources

The adapted Difpolmine methodology has used the GIS based distribution and pollution transport model of the runoff.

The main pollution pathways were identified (1.1) and the Conceptual Model (1.2) was developed. The runoff water was considered to be the main pollution pathway in the model, given the topography (steep slopes), hydrogeology (high infiltration rate) and geology of the area and the site specific processes due to the mineralogical composition of the ore, mine waste material and country rock (leaching, bioleaching, partition). The Conceptual Model (Figure 6.) shows, that the risk posed by the contaminants leached out from the pollution sources is distributed amongst the surface waters, subsurface waters and plant uptake.

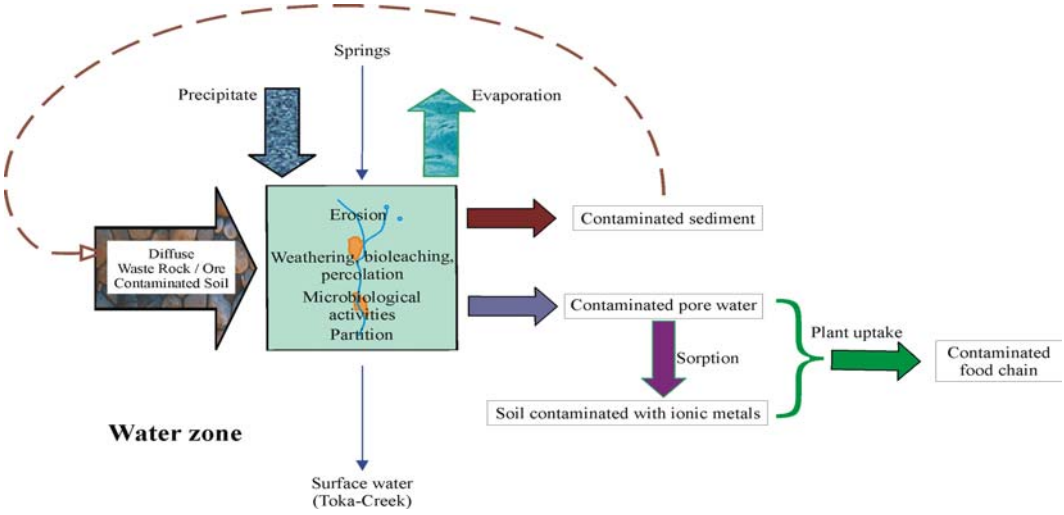

Figure 6. External transport model (conceptual model) of the water zone

The first step in calculating the distribution of the risk was to estimate the distribution of the precipitation in the area (Water Balance: Figure 7.). The Water Balance (1.3) was prepared for the Northern catchment of the Toka creek using the same distribution ratios (%) for the total water catchment of Toka.

WATER BALANCE SHEET OF THE WATER ZONE

POLLUTION TRANSPORT

INCOMING WATER	Denomination of the incoming water	% of total incoming water	Relevant incoming water amount	Water form and components	Processes involved	Data source
	Precipitation	**100%**	**20 712 m^3/ day/10 km^2**	Rain, snow		Hydrological data Meteorological data
	Infiltrated water	**43 %**	**8 972 m^3/ day/10km^2**			Hydrological data
		17 %	3562 m^3/ day/10 km^2	pore water, soil moisture	Infiltration into upper soil layer - Partition - Plant uptake	Microcosm test *In situ* measurements
		0,18%	39 m^3/ day/68 506 m^2	Contamina ted acidic leacheate	Infiltration into mine waste - bioleaching	Microcosm tests *In situ* measurements
		26.00%	5 385 m^3/ day/10 km^2	Subsurface water	Infiltration into deeper layers	Hydrological data
			2 000 m^3/ day/10 km^2	Acidic mine water	Mine outflow	Hydrological data
			3 385 m^3 / day/10 km^2	Drinking water	Pannonian layers	Hydrological data
	Subsurface runoff	**16 %**	**3 248 m^3/ day/10 km^2**	Runoff water	Underground brooks	Field observation Hydrological data
	Surface runoff	**16 %**	**3 241 m^3 / day/10 km^2**	Runoff water	- Runoff - Partition	Transport model for runoff: Measurements Hydrological data
				K_d		
	Erosion			Eroded soil and sediment	- Partition - Bioleaching - Plant uptake	Transport model for erosion: GRASS
	Water in biomass	**4 %**	**767 m^3/ day/10 km^2**	Plant water	Water uptake and incorporation	"Atlas Ecology"
	Vapour	**10 %**	**2 071 m^3/ day/10 km^2**	Evapo-transpiration	Evapo-transpiration	Meteorological data

TOTAL		**100 %**	**20 718 m^3/ day/10 km^2**			
OUTFLOW from the WATER ZONE	**Outflow**	**12 %**	**2 451 m^3/ day/10 km^2**	Toka creek	Surface flow	Flow model and measurements

Figure 7. Water Balance in the Northern catchment of the Toka creek
Meteorological data: OMSZ, National Meteorological Service, 2002

Hydrological data: Terramed Bt. Risk Reduction Plan, 1996
Heinrich, D. and M. Hergt: Atlas Ecology, Springer, Budapest, Berlin, 1995

The Quantitative Water Balance (1.3) was the basis for the quantification of the Flux of Pollutants (4.3), estimation of the Quantitative risk (6.2), using the GIS Flow Accumulation Model, resulting the Flow Accumulation map (2.3), historical data, on site measurement data (3.1), test data (4.2). The GIS Flow Accumulation Model was used also to calibrate the Water Balance Sheet (1.3).

The Flow Accumulation Map (2.3) (Figure 8.) resulted from the Digital Terrain Model (2.2), shows the integrated flow of the rainwater per area, function of the topography. Therefore, the surface area of the point sources and of their watershed area could be read from the GIS Flow Accumulation Map (2.3).

The GIS Flow Accumulation Map (2.3) and the microcosm parameters (3.2) resulted the GIS based Pollution Transport Model (4.3) enabling calculation of the flux of pollution at any point and any time (4.3.1). The emission (4.3) from the pollution sources calculated by the Pollution Transport Model gives a realistic view on the emitted metal amount (4.3.1).

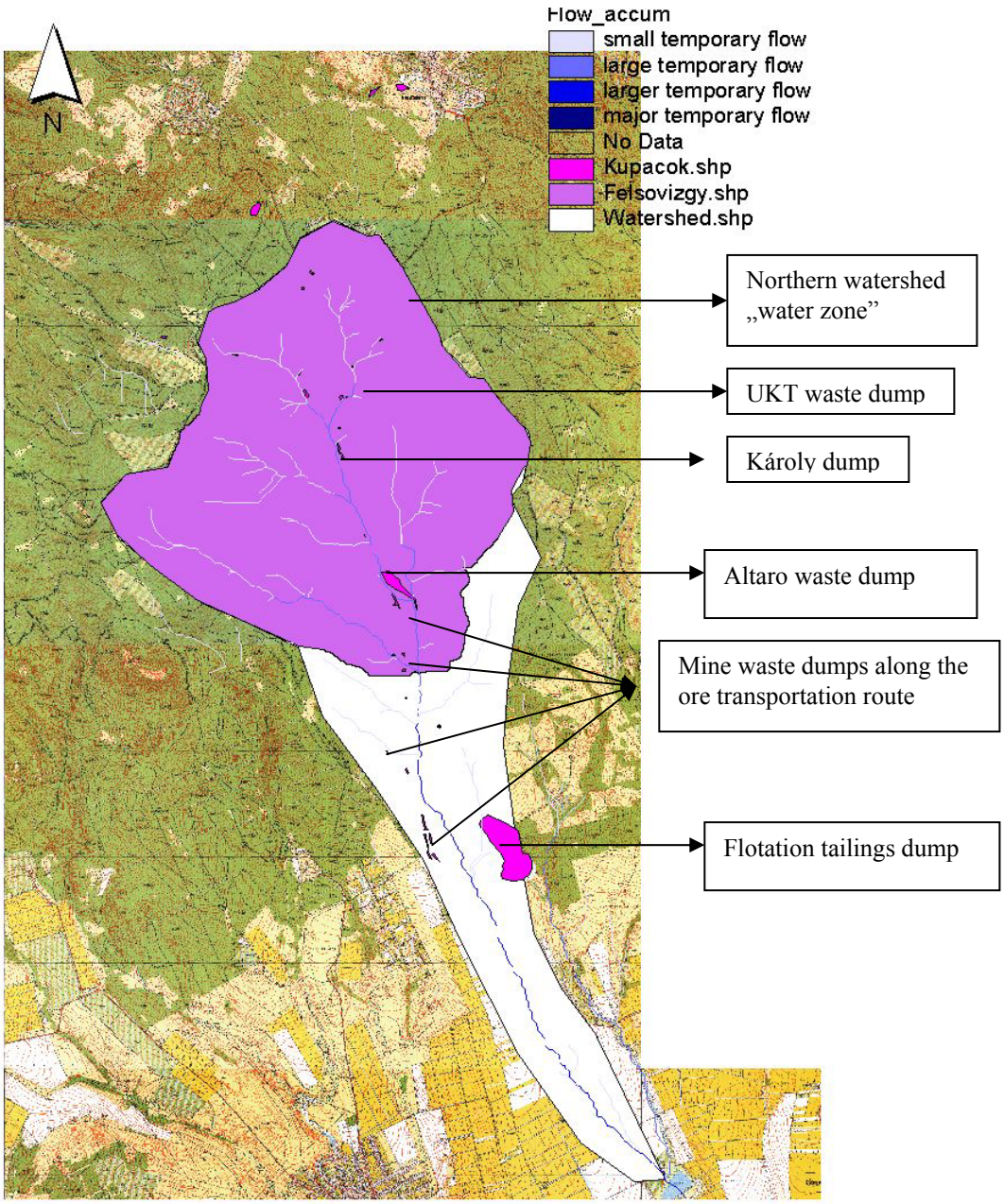

Figure 8. Minor and major temporary creeks based on the Flow Accumulation Model in the Toka watershed

The pollution data were evaluated and visualised by GIS based mapping (3.2). The GIS based pollution map (3.3) of the area was constructed for various metals (As, Pb, Zn) and the distribution of As, Pb and Zn concentration was also shown (Figures 9–12.)

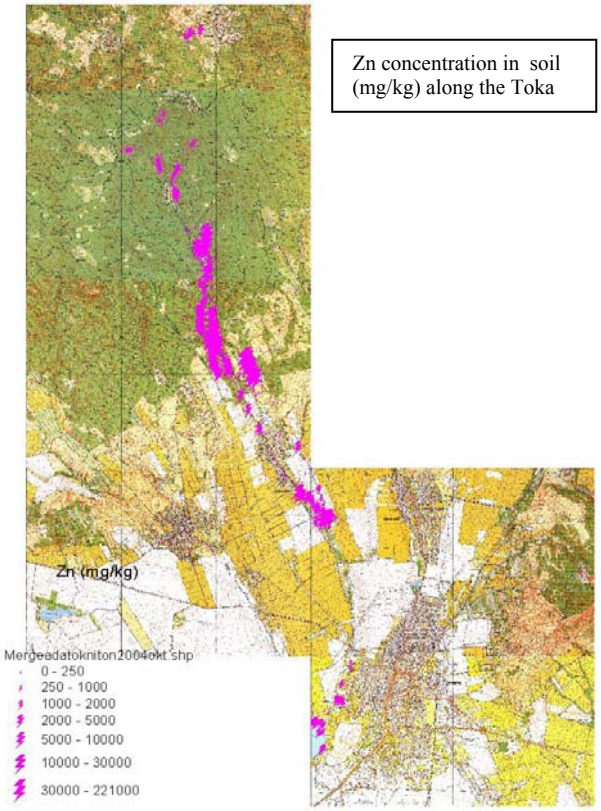

Figure 9. Zn concentration in soil along the Toka creek

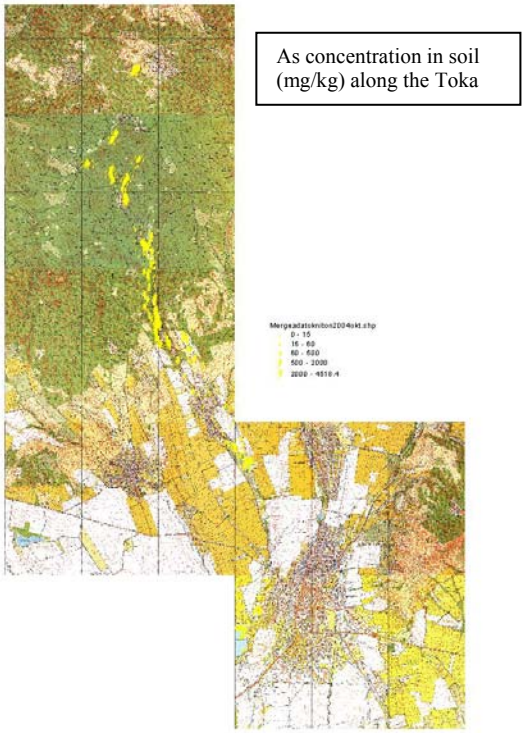

Figure 10. As concentration in soil along the Toka creek

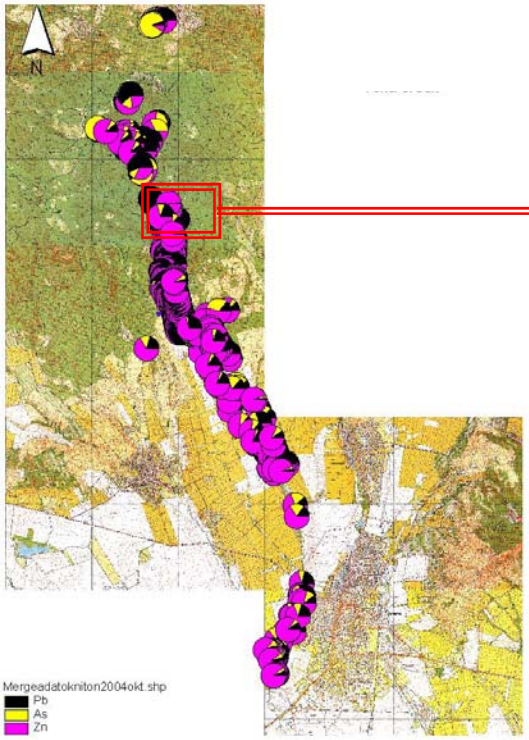

Figure 11. Distribution of Pb , As, Zn in soil along the Toka creek. General view

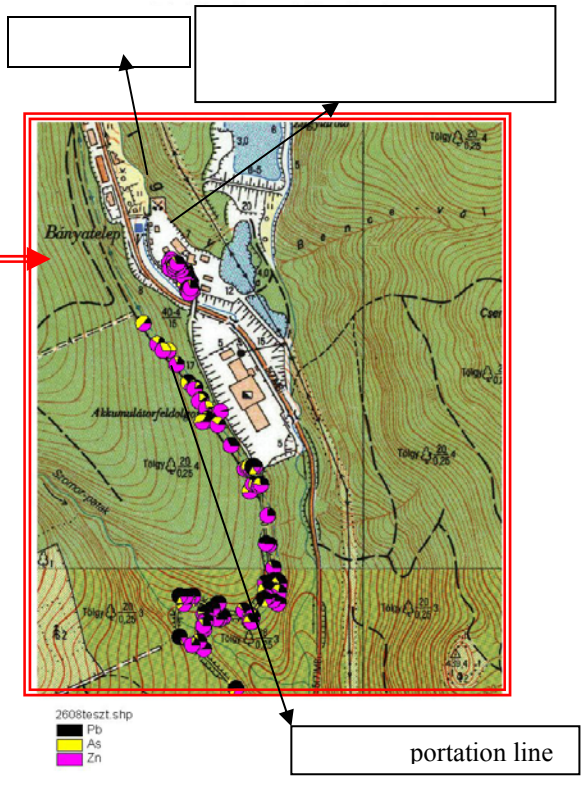

Figure 12. Distribution of Pb, As, Zn along the Northern catchment of Toka creek. Detailed view

The GIS based Pollution Transport Model (4.3) shows the pollution flux (emission) from the pollution sources using the pollution transport parameters (4.2) obtained from "microcosm" parameter modelling (4.1).

The GIS based Pollution Transport Model enables calculation of the flux of pollution at any point and at any time (4.3.1), simulation of remediation scenarios (4.3.2), and of the improved remediation system (4.3.3), and by these the selection of the remediation technology.

Risk characterisation (5.1 & 6.1a, 6.1b)

Risk characterisation includes three levels of assessment:

- Qualitative risk assessment for initial hazard identification and rough ranking
- GIS-based Quantitative Hazard (Generic Risk) Assessment for refined ranking and risk characterisation
- Site specific Quantitative Risk Assessment

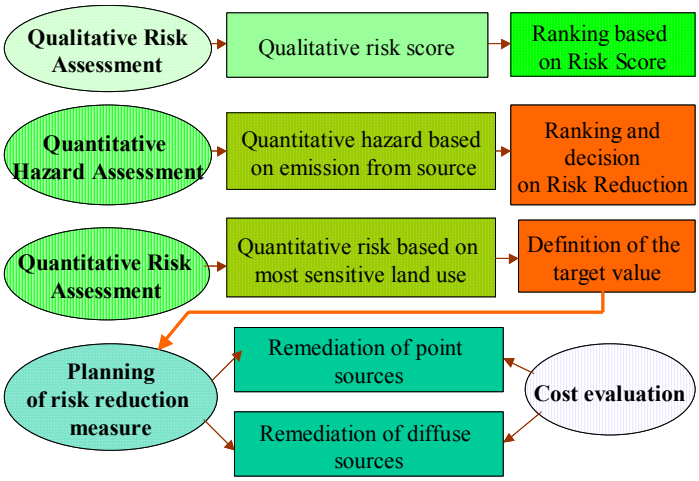

Figure 13. Scheme of the Risk Assessment and Risk Reduction methodology

Preliminary Qualitative Risk (5.1) was assessed based on a site and problem specific questionnaire, resulting a score (point numbers) enabling us to classify (5.2) the identified smaller and larger pollution sources according the following categories: 1. point pollution sources, to be removed (score: 70–100), 2. diffuse pollution sources, to be remedied (score: 50–69), 3. pollution sources not needing further intervention, but re-vegetation (score: 35–49) (5.3). The questionnaire scores consider all parameters that characterise the risk posed by the pollution source. The scores were assigned on the basis of three main categories: a) *source characterisation* including qualitative and quantitative characterisation of the source (maximum score to be assigned: 33) b) *pollutant transport pathways* takes into account hydrogeological, geological and physical characteristics of the area (maximum score to be assigned: 33) c) *receptors* taking into account characteristic features of the land use (maximum score to be assigned: 34).

The evaluation is based on quantitative categories: waste mass, contaminant content, soil characteristics, etc. Evaluation proceeds on two alternative ways: if the pollution and its consequences are proven, the risk score is maximal, if not, detailed site specific assessment is performed. The scores between 0 and 100 indicate three risk categories: 70–100 imposing removal or complete isolation of point sources; 50–70: *in situ* remediation of the point or diffuse sources by combined chemical- and phytostabilisation; under 50: revegetation.

Table 3: The score assigned to the pollution sources and the tonnage of the waste material

Pollution source	Risk score	Tons	Comments
Tailings flotation dam, flotation tailings	99	4 000 000	isolation
Industrial reservoir, sediment	93	70 000	to remove
Ore transportation route, ore	92	30 000	to remove
Precipitate storage, lime precipitate	90,8	50 000	to remove
Agricultural reservoir, sediment	88,8	30 000	to remove
Mud retention, mixed sediment	85,5	30 000	to remove
Altáró waste dump, mine waste	84,5	1 100 000	remediation
Károly waste dump, mine waste	81,5	16 000	to remove
Gyöngyös-Rédei reservoir, sediment	81,3	30 000	to remove
Toka creek , sediment	>80	35 000	to remove
Új Károly-gallery, mine waste I.	79,5	8 000	to remove
Új Károly-galery, mine waste II.	79,5	800	to remove
Emergency dam, various wastes	78,3	3 000	removed
Péter-Pál shaft, mine waste	75,8	16 100	to remove
Katalin gallery, mine waste	73,5	5 000	to remove
14 different waste dumps	55–70	10 000	remediation
15 different waste dumps	>50	10 000	revegetation

Legend: mine waste, sediment, lime precipitate, various wastes diffuse pollution for remediation, diffuse pollution

The Quantitative Hazard Assessment (6.1.a) was undertaken on the basis of the emission of the pollution sources and sub-areas, estimating the pollution transport by water. The direct precipitation (direct water flow) and the indirect water flow were first determined. Then, the metal amount transported by the runoff water was calculated on the basis of the leaching test (4.2). The emitted metal amount was used as a quantitative parameter (6.2.a) to characterise the hazard of the pollution sources. The quantitative emission data of sub-sites or any selected area were used for more precise ranking of the pollution sources, for differentiation between point and diffuse sources and also to estimate the metal load on the watershed.

The Quantitative Risk Assessment (6.1 b) The quantitative risk of the ecosystem is characterised by the Risk Quotient (RQ), which is the ratio of the Predicted Environmental Concentration (PEC) and the Predicted No Effect Concentration (PNEC) (Gruiz et al, 2000). The PEC is given by the measured metal concentrations of the Toka creek water and sediment. The PNEC is defined based on effect based quality criteria obtained from literature and regulatory data (BKH, 1995; Swartjes, 1999; http://www.sitespollues.ecologie.gouv.fr/). According to the site specific Quantitative Risk Assessment of the Toka catchment area the risk quotient (RQ=PEC/PNEC) is higher than 1 (RQ>1). The target risk value is RQ = or < 1. The aim is to reduce PEC to the PNEC value. Having the target concentration in the Toka creek (PNEC) and the Natural Risk Reduction Capacity of the site located between the source and the recipient Toka creek, the maximum permitted emission from the point and diffuse sources able to ensure the PNEC value in the Toka creek is calculated.

The solid transport by erosion is included in the conceptual model. However the Quantitative Risk Assessment at this stage was not focussed on the solid phase (sediment) transport by runoff, like it did in case of the Salsigne site (Pottecher, 2002), but more on the mobile metal transport by surface water. The calculated Quantitative Risk was calculated in light of a conservative approach attributing minimum value to the Natural Risk Reduction Capacity of the site and assuming maximum emission from the sources when calculating the Targeted Risk Reduction %.

In Gyöngyösoroszi after having completed the differentiation between the point and diffuse pollution sources (5.3), the most suitable risk reduction measures were selected (7.1). The point sources will be excavated and confined and the excavated material will be transferred onto the top of the tailings dump (7.2). Given that the erosion of the polluted soil leads to the highest toxic metal emission from the pollution source, once the point sources are excavated and confined, the emission of the toxic metal will diminish considerably. The residual pollution will be treated as diffuse pollution together with the already existing diffuse pollution sources (on the basis of our ranking), applying the Difpolmine approach: the diminution of polluted runoff and of erosion (7.2).

The main objective in case of Gyöngyösoroszi is to reduce the pollution flux from the pollution sources, which involves mitigation of the leaching process and stopping erosion of the polluted soil.

After removal of the point sources and mitigation of the emission from the residual pollution sources the actual toxic metal concentration in the Toka creek could be reduced by the calculated efficiency of the “risk reduction box”(7.2).

The Natural Risk Reduction Efficiency of the site was calculated by comparing the calculated emitted metal content of the sources (4.2) with the actual metal concentration measured in the surface water (3.1.1). The NRRE of the Toka box is a generic parameter, the ratio of the emitted metal concentration and the measured metal concentration in the outflow of the box.

The maximum permitted emission (6.3) from the diffuse and residual of point sources in the Toka catchment was calculated from the targeted Effect Based Quality Criteria (EBQC) of the Toka creek (set by expert studies) and from the minimum Risk Reduction Capacity (Efficiency) of the site ($NRRE_{min}$) (calculated). In light of a conservative approach, the $NRRE_{min}$ is the ratio between the metal emission from a minimum concentration waste source and the actual metal concentration in the surface water. The target concentration (6.3) used for site remediation can be calculated from the permitted emission values.

According to the Difpolmine approach, if the diffuse source is barely vegetated phytostabilisation combined with chemical stabilisation is performed.

Laboratory tests were performed on real soil samples (4.2) to determine the amendments (immobilising agents like fly ash, iron oxide) to be added to the soil and the plant species able to grow on the substrate. Based on the results of the laboratory experiments the cost calculations and technology planning for 7 years of remediation has been worked out (8.1).

A comparison between the costs of several remediation alternatives considered for the Gyöngyösoroszi site has been done (4.3.2) to substantiate cost efficiency of the chemical and phytoremediation option.

The implementation of the combined chemical+phytoremediation alternative will reduce the emission of the single sources and the total site and consequently the pollution load in the surface water flow. The mine water will have to be treated separately (4.3.3) (Figure 21.). A water treatment methodology (liming) has been planned for the mine outflow (4.3.3).

Results and discussions on the technical feasibility of the method

The main target of the methodology adapted to the Hungarian site was to determine the risk of the pollution sources and work out a risk based management concept that substantiates a risk based remediation approach.

The main site-specific quantitative parameters for description of the risk in Gyöngyösoroszi area are:

- Rain water directly on the surface of the pollution source
- Surface (and subsurface) runoff running through the pollution source
- The metal amount leached out and transported from the pollution source.

The starting point is the Conceptual Model that takes into account the pollution sources and the hydrogeological conditions of the area. Then the Water Balance of the area was pőroduced. The total pollutant emission was calculated using the data of the Water Balance and the GIS-based Flow Map.

According to our approach the risk of point sources that are still in place within a water catchment is dependent not only on the metal concentration, waste material tonnage and surface area of the dump but to a large extent on the water amount that runs through the pollution source, which results from the size of the watershed of the waste dump. The GIS approach allows estimation of every pollution source (mine waste dump) as an individual water catchment. The surface area of the waste dump and the topography around the pollution source determine the size of the watershed of every individual waste dump, and therefore the water volume likely to run through it and directly on its surface. The Table below gives the surface area of the point sources and their watershed area read from the GIS Flow Accumulation Model

Table .4. Surface area of the waste dumps and of their watershed

Waste dump	**Surface area of the dump**	**Watershed of the waste dump**	**Cell size**	**Surface area of the waste dump watershed**
	m^2	cell number	m^2	m^2
Total dumps	197 000	8 228	100	822 800
Toka total waste dumps without the flotation tailings dump	44 000	4 109	100	410 900
Total diffuse sources	24 000	2 000	100	200 000
Total residual from point + diffuse	68 000	6 220	100	622 000
Total Toka water water catchment		250 000	100	25 000 000

The Flotation Tailings dump will be covered and insulated within the National Remediation Programme, for this reason it is not included in our calculations.

Following the above idea and using the above data, the ratio (%) of the total surface are of the waste dumps to the total area of Toka catchment was compared with the ratio (%) of the water catchment area of the waste dumps to the total area of Toka water catchment. This enabled estimation of the risk posed by the water running through the watershed of the waste dumps in comparison to the risk posed by the water that gets onto the surface of the dump directly (direct rain):

The ratio of the total **surface area of the waste dumps** to the total area of **Toka water catchment** is 0,1%:

The ratio of the total **water catchment area of the waste dumps** to the total area of **Toka water catchment** is 1,6%. This makes big difference and should be taken into consideration.

In terms of metal leaching from waste dumps (point and diffuse pollution sources) it is not only the direct rain water onto the surface of the waste dumps that has important role in the transport, but as one could see from field observations, also the water that runs through the dump and the subsurface (hidden temporary flows). The runoff volume was calculated from the GIS based flow accumulation model

Table 5. Direct runoff produced by the yearly precipitation reaching the surface of the dumps (in the 1st year)

	Waste dump	**Area**	**Direct surf. runoff**	**Runoff volume from the surface**
		m^2	mm/year	m^3/year
	Total dumps	**198 000**	326	**64 000**
	Toka total waste dumps without the flotation tailings dump	**44 000**	326	**14 500**
	Total diffuse sources	**24 000**	326	**7 800**
	Point +diffuse	**68 000**	326	**22 000**

Table 6. Indirect runoff volume produced by the yearly precipitation running through the watershed of the dumps

Waste dump	Watershed area	Run-through	Runoff volume through watershed
	m^2	mm/year	m^3/year
Total dumps	**823 000**	326	**270 000**
Toka total waste dumps without the flotation tailings dump	**411 000**	326	**134 000**
Total point + diffuse	**622 000**	326	**203 000**

Leaching of metals from pollution sources and the characteristic parameters of the process were set based on a complex (physical-chemical-biological) leaching test (microcosm) using the most polluted mine waste material in the area. Site specific processes like weathering of the sulphide ore containing waste rock and leaching coupled with the microbiological sulphide oxidation process, natural decontamination of the leachate by high sorption capacity forest soil were simulated in microcosms. Two typical cases were modelled in four microcosms: bioleaching within a large waste dump (the leachate does not reach the original soil layer) and bioleaching in a waste dump in contact with surrounding soil (the leachate does reach the soil). The quantity and quality (pH, As, Cd, Cu, Pb, Zn content) of the leachate was measured at regular time intervals. The key parameters for environmental risk assessment like the rate of acidification and metal mobilisation, the metal concentration of the emitted leachate were determined from the results of the leaching experiments. Two different leaching efficiencies were calculated compared to the total metal content (aqua regia extract) and to the mobile metal content (acetate buffer extract) of the leached waste

To estimate the metal amount transported yearly by the runoff water generated by the annual rain per polluted area the metal concentration of the leach resulted from the microcosm experiment was used. The GIS approach enabled calculation of the pollution flux of every individual source using the runoff volume derived from the Flow Accumulation (function of the watershed size and annual precipitation) and the metal concentration of the leachate from the complex microcosm leaching test.

The yearly metal amount was calculated by multiplying the average metal concentration of the leachate obtained from the bioleaching microcosm test with the runoff volume produced by the annual precipitation. Direct runoff flowing straight onto the surface of the pollution source and indirect runoff volume running through the surface of the pollution source were differentiated and the metal pollution flux resulted from each flow was calculated. To give the total metal amount emitted from the pollution source the sum of the metal amount transported by the above two runoff volumes was given.

The calculated total metal amount emitted from the identified pollution sources during the first year resulted from the following data:

- Runoff water percentage from the annual precipitation in the Water Balance: 15.68% (surface runoff) + 15.65% (subsurface runoff) + 11.83% (Toka runoff) = 43,16 %
- Yearly runoff relevant to the above % is: 756 mm/year x 0,4316 = 326 mm/year (756 mm/year is the average annual precipitation in the Toka Northern catchment= 0.756 m^3/m^2/year)
- Total surface area of the mine waste dumps plus diffuse minus the flotation tailings dump: 68 000 m^2 (Table 4.)
- Direct flow (rain) volume/annum on the total surface of the waste dumps and diffuse sources:. 68 000 m^2 x 0.326 mm/year= 22 000 m^3/year (Table 5.)
- Indirect flow (runoff) volume/annum through the total surface of the mine waste dumps and diffuse sources: 622 000 m^2 * 0,326 mm/year = 203 000 m^3/year (watershed area read from the GIS Flow accumulation, Table 6.)
- Minimum, medium and maximum total metal concentration of the mine waste material used in the bioleaching microcosm test: minimum, medium and maximum values (Table 7)
- Metal concentration of the leach obtained from the microcosm bioleaching test: minimum, medium and maximum emission (Table 8)

Table 7. Total metal concentration of various quality mine wastes in the area (minimum, medium and maximum grade) used in the bioleaching microcosm test

Metals	Total metal concentration of a mine waste (minimum) mg/kg	Total metal concentration of a mine waste (medium) mg/kg	Total metal concentration of a mine waste (maximum) mg/kg
As	44	100	216
Cd	1	3	12
Cu	25	50	107
Pb	295	600	13 100
Zn	370	800	2 155

Table 8. Metal concentration of the leachate obtained from the bioleaching microcosm test using the above waste qualities (minimum, medium and maximum emission)

Metals	Minimum emission µg/lit	Average emission µg/lit	Maximum emission µg/lit
As	150	340	700
Cd	100	300	1200
Cu	400	800	4 710
Pb	100	203	3 600
Zn	25 000	54 135	163 000

The average and maximum emitted metal amount per year was calculated using the medium and highest concentration mine wastes in the area. The minimum emission was used to generate the Natural Risk Reduction Efficiency of the site (NRRE).

Calculation of the metal (As, Cd, Cu, Pb, Zn) amount leached out yearly (in the highest risk period) by the runoff water (mm/year) reaching the surface area of mine waste dumps and diffuse sources (direct rain) is shown in the table below:

Table 9. The yearly average and maximum metal amount resulted from leaching by direct runoff in the Northern catchment of Toka creek

	Runoff on the surface (direct rain)	Medium – Maximum metal conc. leachate	Medium – Maximum metal amount
	m^3/year	µg/lit = (10^{-3}g/m^3)	kg/year
As	22 000	340 – 700	**7 – 16**
Cd	22 000	300 – 1 200	**7 – 26**
Cu	22 000	800 – 4 710	**18 – 103**
Pb	22 000	203 – 3 600	**4 – 479**
Zn	22 000	54 135 – 163 000	**1 190 – 3 597**

The metal amount leached out yearly in the first years (highest risk period) by the runoff water (mm/year) through the watershed area (indirect rain) is shown below. It is to be noted that only 50% of the leach concentration from the microcosm test was used because the leaching efficiency of the runoff water flowing through the watershed ranges from 0 and 100%, function of the flow conditions and water amount.

Table 10. The yearly average and maximum metal amount resulted from leaching by the indirect runoff in the Northern catchment of Toka creek

	Runoff through the waste dump(indirect)	Medium – Maximum metal conc. leachate	Medium – Maximum metal amount
	m^3/year	µg/lit = (10^{-3}g/m^3)	kg/year
As	203 000	170 – 370	**35 – 75**
Cd	203 000	150 – 600	**30 – 122**
Cu	203 000	400 – 2 360	**81 – 476**
Pb	203 000	100 – 1 790	**20 – 363**
Zn	203 000	27 068 – 81 770	**5 495 – 16 579**

The total metal amount leached out per year per total water catchment is the sum of the direct runoff on the dump surface and runoff water (m^3/year) through the watershed area (indirect rain).

The total calculated yearly emitted metal (kg/year) transported in the 1st years (highest risk period) by the direct (Table 9) + indirect rain running off and through (Table 10.) the total surface of the mine waste dumps and diffuse sources is as follows:

Total yearly emitted metal amount from the total surface area of maximum metal grade/concentration point and diffuse pollution sources:

As: 16 kg + 75 kg = **91 kg**; **Cd**: 26 kg +122 kg = **148 kg**; **Cu**: 103 kg + 476 kg = **579 kg**;
Pb: 79 kg + 363 kg = **442 kg**; **Zn**: 3 597 kg + 16 579 kg = **20 176 kg**.

Total annually emitted metal amount from the total surface area of average metal grade/concentration point and diffuse pollution sources:

As: 7 kg + 35 kg = **42 kg**; **Cd**: 7 kg +30 kg = **37 kg**; **Cu**: 18 kg + 811 kg = **829 kg**;

Pb: 4 kg + 20 kg = **24 kg**; **Zn**: 1 190 kg + 5 495 kg = **6 685 kg**.

The calculations are based on the average and maximum emission of the mine waste dumps and diffuse pollution areas (microcosm test).

When defining the quantitative hazard based on the metal emission, the maximum value of the emission was taken into account in light of a pessimistic approach. Total emission, and consequently the water transported metal load will decrease in time exponentially. The initial phase of this process (the highest risk period) was studied and all the calculations were based on it in our pessimistic model.

In this iterative Risk Assessment process the Quantitative Hazard and Quantitative Risk were calculated only based on the metal transport by runoff and surface water. The solid phase transport by water was not modelled separately. However the PEC value resulted from our measurements – metal concentration in the Toka-water – incorporates the pollution deriving from the water-transported sediment too.

The Risk Assessment currently is being refined, by adding Erosion Modelling to it, enabling us to have the solids transport considered separately in the approach. Erosion modelling is in progress, however the model has not yet been validated, therefore this report does not include any of the results. The RUSLE (Revised Universal Soil loss Equation) was used in our erosion prediction model. It calculates the average soil loss per unit area. It is a product of six factors representing rainfall and runoff erosivity (R), soil erosivity (K), slope length (L), slope steepness (S), management practice (C), conservation; practice (P).

In our work the calculated maximum emitted metal amount is the basis for determining the contribution to the quantitative hazard of each point and diffuse pollution source. The calculated emission is used as a semi-quantitative relative risk value for differentiation between the sources. If one would like to estimate the pollutant flow along one of the pathways into the Toka creek, one has to take into account the risk reducing capacity of the site (dilutions, sorption in the soil, partition between phases, changes in the chemical form and as a consequence changes in the mobility of the metals, bioaccumulation, etc.). For this reason the Natural Risk Reduction Efficiency of the site was generated/calculated by comparing the emitted metal content of the leachate (based on the results of the microcosm experiments) with the actual metal concentration measured in the surface water. When calculating the NRRE of the site the minimum emitted metal concentration was used. (Figure 14., Figure 15.)

Table 11. Calculation of the Natural Risk Reduction Efficiency (NRRE) of the Toka box based on the minimum concentration leachate

Waste dumps emitted leachate concentration (estimate based on microcosm test) (Ecmin)				Toka creek measured, average conc. (µg/lit)				Risk Reduction Efficiency (NRRE) of the Toka box decrease ratio and %			
As	Cd	Pb	Zn	As	Cd	Pb	Zn	As	Cd	Pb	Zn
µg/lit	µg/lit	µg/lit	µg/lit	µg/lit	µg/lit	µg/lit	µg/lit				
150	100	100	25 000	50	2	30	800	**3.0 (66%)**	**50 (98%)**	**3.3 (70%)**	**30 (97%)**

The NRRE tool can be used to calculate:

1. the Maximum Permitted Emission from the sources if only the NRRE works (MPE),
2. the targeted Risk Reduction Efficiency (TRRE) by combined chemical and phytoremediation to reach MPE.
3. to plan the removal of the sources, if target concentration in the Toka river is known (EBQC).

Given that the work focussed on the risk of toxic metals transported by the surface water, the target metal concentration in the Toka creek was set using effect based water quality criteria given by expert studies on the area, taking into account the different effect based quality criteria in various countries (BKH, 1995; Swartjes, 1999; http://www.sitespollues.ecologie.gouv.fr). The set criteria are based on environmental toxicity data. Risk levels and environmental quality objectives in some countries are or will be considered tools in the execution of environmental policy. Due to the scientific deduction methods and the consequences associated with chosen risk levels the comparability of the environmental quality criteria in the various countries is poor (BKH, 1995). The necessity of setting the Effect Based Quality Criteria (EBQC) for the Hungarian demonstration site occurred for three reasons: 1. Lack of quality criteria / limit values on surface water in Hungary. The water quality is regulated and inspected based on standards imposed on the discharge/emission from various industries. 2. Location of the Hungarian demonstration site in the vicinity of the Mátra Natural Reservation classifies the area in the sensitive water usage category, for which reason the minimum EBQC values (**$EBQC_{min}$**) were generated. 3. Due to the geological setting and former mining activity the background concentration values in some sub-areas are higher. For which reason the maximum EBQC values (**$EBQC_{max}$**) were derived.

Table 12. Effect based quality criteria (EBQC) (BKH Consulting Engineers, Holland (1995)

Effect based environmental quality criteria	**As**	**Cd**	**Pb**	**Zn**
Surface water	µg/lit	µg/lit	µg/lit	µg/lit
HU standard for ground water	*25*	*5*	*10*	*200*
Holland	8.6	0.35	10	6
Canada	50	0.01–0.06	1–7	30
US-EPA	190	1.1	3.2	110
Swedish	0.45	0.045–0.09	0.6–1.2	4.5–9
Danish	4–9	2.5	5.6–9.2	86–110
French	10	5	25	3000
UK	50		4–20	8–50
EBQC min	3	0.3	2	20
EBQC max	10	1	10	100

Knowing the target EBQC of the Toka creek (set by expert studies), which is the Predicted No Effect Concentration in our risk calculations and the effect of natural risk reduction (calculated), the maximum permitted emission (MPE) from the diffuse and residual sources in the Toka catchment was calculated, using the minimum $NRRE_{min}$ (pessimistic estimation) based on the **minimum emission** (Table 8. and Figure 14.).

Table 13. Maximum Permitted Emission (MPE) based on minimum/maximum EBQC if only NRRE works

Target EBQC of Toka creek $TEBQC_{min}$, $TEBQC_{max}$ (PNEC)					Natural Risk Reduction Efficiency ($NRRE_{min}$) of the Toka box					**Maximum Permitted Emission if only NRRE works (MPE)**			
As	Cd	Pb	Zn	pH	As	Cd	Pb	Zn	pH	As	Cd	Pb	Zn
µg/lit	µg/lit	µg/lit	µg/lit						incr.	µg/lit	µg/lit	µg/lit	µg/lit
3.0	0.3	2	20		3.0	50	3.4	30		**4.5**	**15**	**14**	**600**
10	1	10	100		3.0	50	3.4	30		**30**	**50**	**33**	**3000**

The permitted emission values will be used as target concentrations for site remediation. The target emission (MPE) is dependent on the predicted surface water quality (TEBQC) and on the natural risk reduction potential (NRRE) of the site. The scheme of calculating the NRRE and the Maximum Permitted Emission (MPE) of the site based on the maximum TEBQC (non-sensitive water usage) is shown in Figure 14.

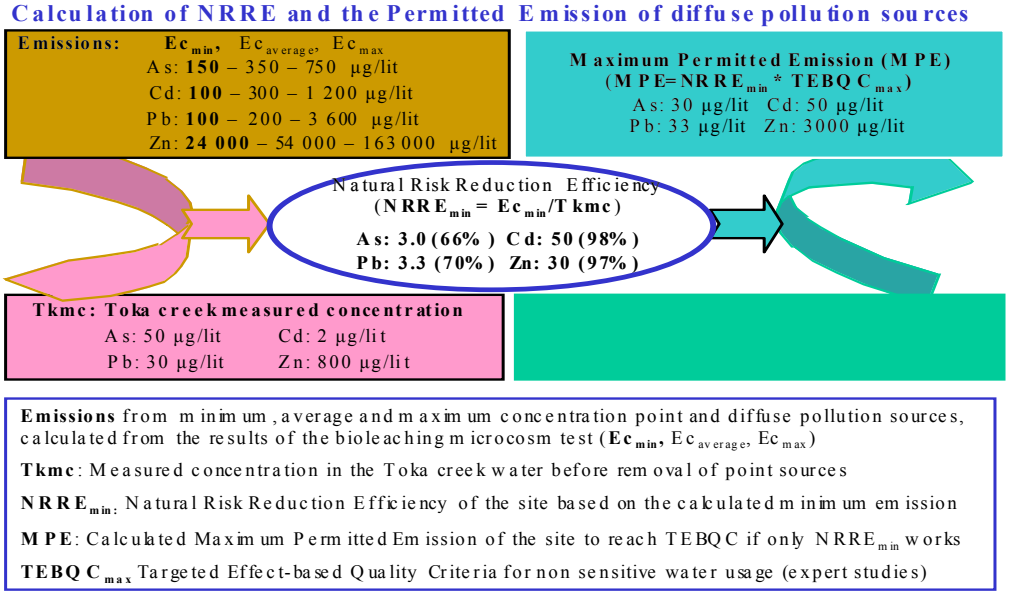

Figure 14. Scheme of calculating the Natural Risk Reduction Efficiency (NRRE) of the site and the Maximum Permitted Emission (MPE) to reach target concentration in the Toka creek set for non-sensitive water usage ($TEBQC_{max}$)

The scheme of calculating the NRRE and the Maximum Permitted Emission (MPE) of the site based on the minimum EBQC is shown in Figure 15.

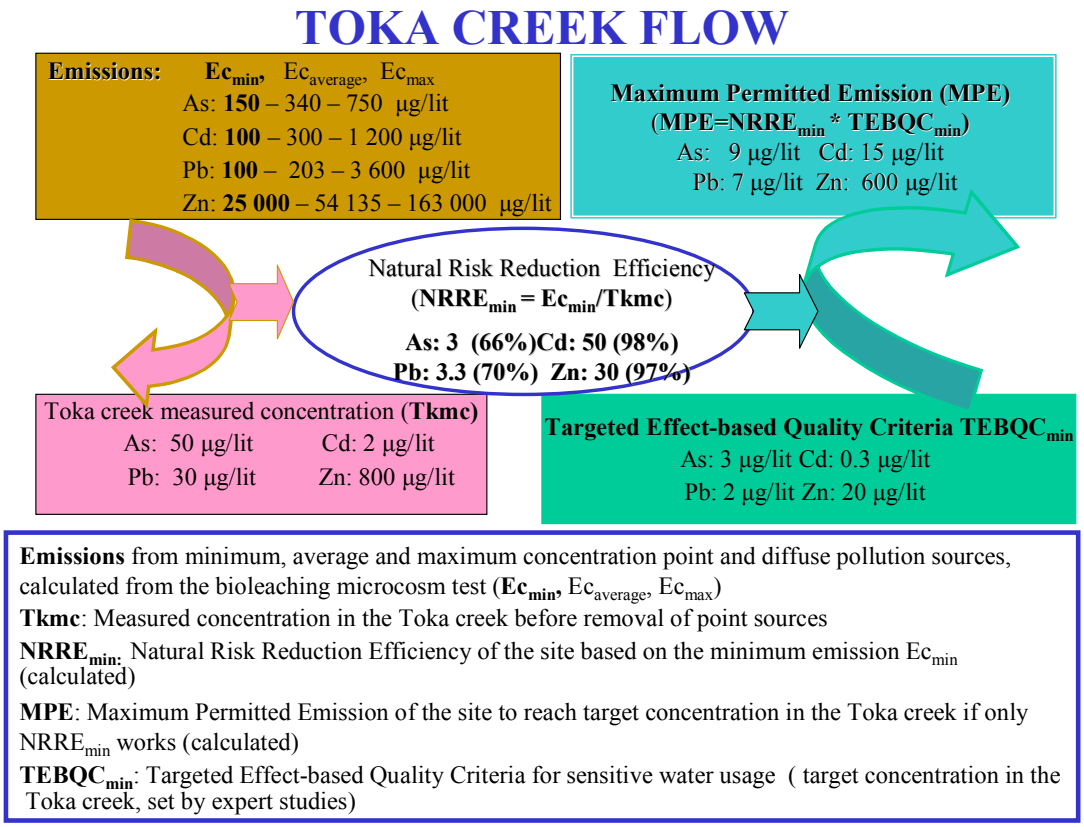

Figure 15. Scheme of calculating the Natural Risk Reduction Efficiency (NRRE) of the site and the Maximum Permitted Emission (MPE) to reach target concentration in the Toka creek set for sensitive water usage ($TEBQC_{min}$)

The Natural Risk Reduction Efficiency (NRRE) alone cannot lower the risk to such extent that the Maximum Permitted Emission values (MPE) are reached. For example in case of a non sensitive water usage As is 150 instead of 30 , Cd is 100 instead of 50, Pb is 100 instead of 33 and Zn is 25 000 instead of 3000 µg/lit.

Further risk reduction consists mainly of excavation and confinement of point sources and chemical+phyto-stabilisation of diffuse sources and of the residual waste after removal of the point sources.

The main objective in case of Gyöngyösoroszi is to reduce the pollution flux from the pollution sources, which involves mitigation of the leaching process and stopping erosion of the polluted soil.

The choice of the remediation process for diffuse pollution is based on:

- the toxic metal concentration (Zn, Pb, As)
- the toxic metal (Zn, Pb, As) emission flux by runoff
- the access to the pollution source
- cost evaluation.

According to the Difpolmine approach, if the diffuse source is barely vegetated phytostabilisation combined with chemical stabilisation is performed.

The risk reduction requirements of the site will be controlled by the Targeted Risk Reduction Efficiency (%), which includes both the efficiency of chemical and phytostabilisation. The targeted Risk Reduction Efficiency (TRRE) of combined chemical + phytoremediation was calculated taking into account the maximum permitted emission (MPE) to reach EBQC for non-sensitive water usage and the concentration of the emitted leachate from a maximum and average concentration sources (Table 8). Having a targeted Risk Reduction Efficiency (TRRE) and the efficiency of chemical stabilisation, the required maximum efficiency of phytostabilisation can be estimated.

Figure 16. and 17. show the scheme of calculating the Targeted Risk Reduction Efficiency (TRRE) in case of a highly polluted (maximum emission) and less polluted site (average emission), respectively, complying with the requirement on non-sensitive water usage after remediation ($TEBQC_{max}$).

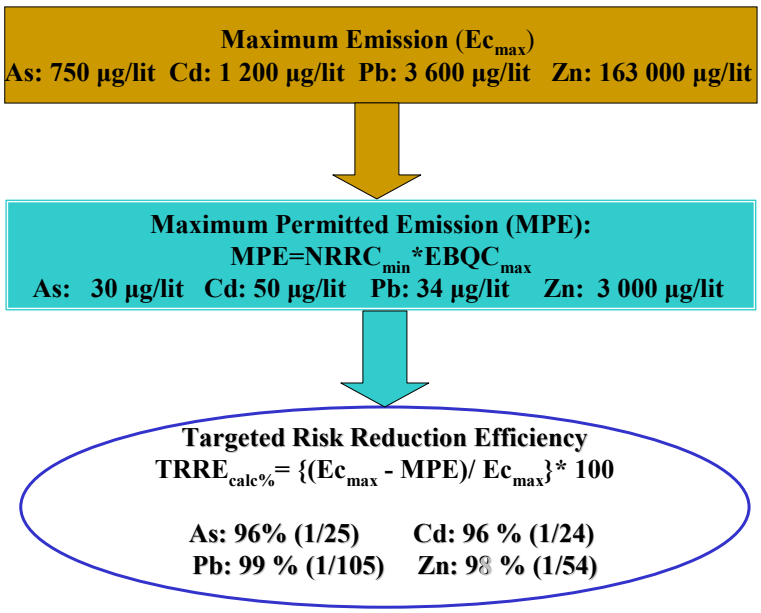

Figure 16. Scheme of calculating the Targeted Risk Reduction scale in case of maximum emission

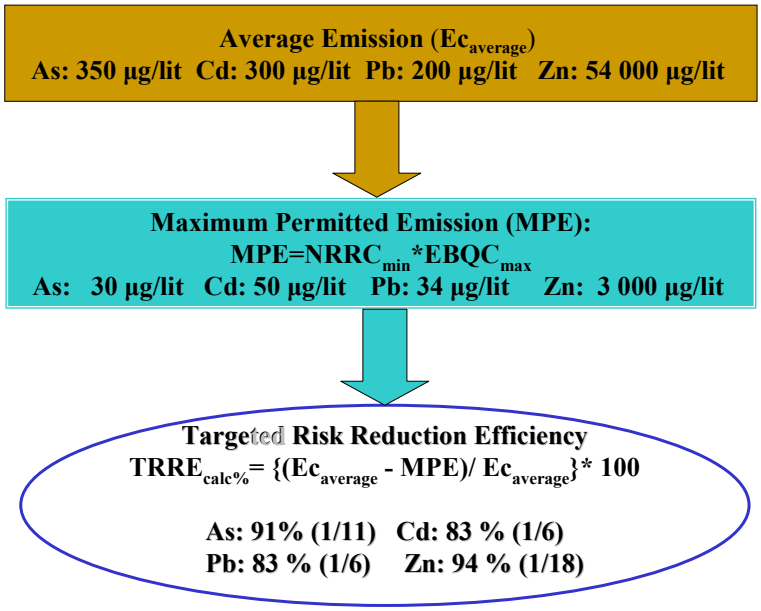

Figure 17. Scheme of calculating the Targeted Risk Reduction scale in case of average emission

To select the most suitable chemical stabiliser and optimise technological parameters of combined chemical and phytostabilisation, laboratory microcosm experiments were done.

Two different fly ash and five other additives were tested as chemical stabilisers (raw phosphate, lime, lignite, alginite and the mixture of these) in microcosms. The stabilisation process was monitored during the experiment by an integrated methodology, which combined physical-chemical analysis with ecotoxicity testing. The change of the soluble and mobile metal fraction during the experiment was analysed in the water- and in the acetate extracts of the stabilised soil, and compared to the aqua regia extractable total metal concentration. Plant uptake was modelled by an extract of a solvent mixture of acetic acid and EDTA. The metal content of the extracts was analysed by Atomic Emission Spectrometry. The actual bio-available fraction before, during and after stabilisation was measured by a new bio-concentration (plant-uptake) test, which is a self-developed rapid plant test combined with the chemical analyses of the biomass. To measure the adverse effects of the pollution and predict the environmental risk of the soil, the stabilisation process was followed also by environmental toxicity testing. The results of the tests and the chemical analyses were evaluated together. Both the chemical and toxicological results proved the highest efficiency of fly ash. The

decrease in dissolvable metal content and toxicity was observed already 21 days after fly ash addition and became considerable after 4 months of treatment. During this time the mobile Cd and Zn concentration in the fly ash treated Gyöngyösoroszi soil decreased by 60–99,8%. The stabilising effect of a single treatment remained unchanged after 2,5 years. The results of the microcosm experiments after 21 days and 4 months flyash treatment are shown in Table 14. and Table 15.

Table 14. Toxic metal concentration decrease in the water extract of the Gyöngyösoroszi soil (Gy) treated with 1w%, 2w% and 5w% flyash (PA) after 21 days in microcosms

Treated material	MU	As	Cd	Cu	Pb	Zn
Gyo soil initial	mg/kg	ND	1,00	0,66	ND	171,0
PA flyash	mg/kg	ND	ND	ND	0,09	0,43
GYPA1 theoretical (soil with 1% flyash addition)	mg/kg	ND	0,99	0,65	ND	169,26
GYPA2 theoretical (soil with 2% flyash addition)	mg/kg	ND	0,98	0,65	ND	167,59
GYPA5 theoretical (soil with 5% flyash addition)	mg/kg	ND	0,95	0,63	ND	162,47
GYPA1 measured concentration after treatment	mg/kg	ND	0,34	0,35	ND	39,86
GYPA2 measured concentration after treatment	mg/kg	ND	0,15	0,31	ND	10,91
GYPA5 measured concentration after treatment	mg/kg	ND	0,01	0,41	0,03	0,55
GYPA conc. decrease compared to the theoretical or corrected conc. (mg/kg)						
GYPA1 theoretical -GYPA1 measured	mg/kg	ND	0,65	0,30	ND	129,43
GYPA2 theoretical –GYPA2 measured	mg/kg	ND	0,83	0,34	ND	156,68
GYPA5 theoretical –GYPA5 measured	mg/kg	ND	0,94	0,22	ND	161,92
GYPA conc. decrease compared to the theoretical or corrected conc (%)						
GYPA1 theoretical -GYPA1 measured		ND	66	46	decr	76
GYPA2 theoretical –GYPA2 measured		ND	85	52	decr	99
GYPA5 theoretical –GYPA5 measured		ND	99	36	decr	100

ND*: non-detectable; decr.**: decrease

Table 15. Toxic metal concentration decrease in the water extract of the Gyöngyösoroszi soil (Gy) treated with 1w%, 2w% and 5w% flyash (PA) after 4 months in microcosms

Treated material	MU	As	Cd	Cu	Pb	Zn
Gyo soil initial	mg/kg	ND*:	1,31	0,57	ND	85,93
PA flyash	mg/kg	ND*:	ND*:	ND*	0,09	0,43
GYPA1 theoretical (soil with 1% flyash addition)	mg/kg	ND*:	1,30	0,56	ND*:	85,07
GYPA2 theoretical (soil with 2% flyash addition)	mg/kg	ND*:	1,28	0,56	ND*:	84,22
GYPA5 theoretical (soil with 5% flyash addition)	mg/kg	ND*:	1,24	0,54	ND*:	81,66
GYPA1 measured concentration after treatment	mg/kg	ND*:	0,13	ND*:	0,05	21,95
GYPA2 measured concentration after treatment	mg/kg	ND*:	0,08	ND*:	0,01	2,83
GYPA5 measured concentration after treatment	mg/kg	ND*:	ND	ND*:	0,03	ND*:
GYPA conc. decrease compared to the theoretical or corrected conc. (mg/kg)						
GYPA1 theoretical -GYPA1 measured	mg/kg	ND	1,17	ND	ND	63,12
GYPA2 theoretical –GYPA2 measured	mg/kg	ND	1,20	ND	ND	81,39
GYPA5 theoretical –GYPA5 measured	mg/kg	ND	decr	ND	ND	
GYPA conc. decrease compared to the theoretical or corrected conc. (%)						
GYPA1 theoretical -GYPA1 measured		ND	90	decr	decr	74
GYPA2 theoretical –GYPA2 measured		ND	94	decr	decr	97
GYPA5 theoretical –GYPA5 measured		ND	decr	decr	decr	decr

ND*: non-detectable; decr.**: decrease

The microcosm experiments on chemical stabilisation demonstrated that 2% and 5% fly ash addition to the polluted soil resulted 60 to 99% reduction in the dissolvable Zn and Cd metal content of the soil. The field experiments on chemical+phytoremediation are being planned and will start this year.

Based on a conservative approach the effect of chemical stabilisation was calculated in case of maximum and average emission values (Table 8.), resulting the emission reached only with chemical stabilisation, based on the efficiencies resulted from microcosm test. The scheme of estimating the effect of chemical stabilisation applied to an area with maximum emission is shown in Figure 18. and 19. The reduced emission values are given both for a site of average and maximum emission and are compared to Maximum Permitted Emission values relevant to non-sensitive and sensitive water usage.

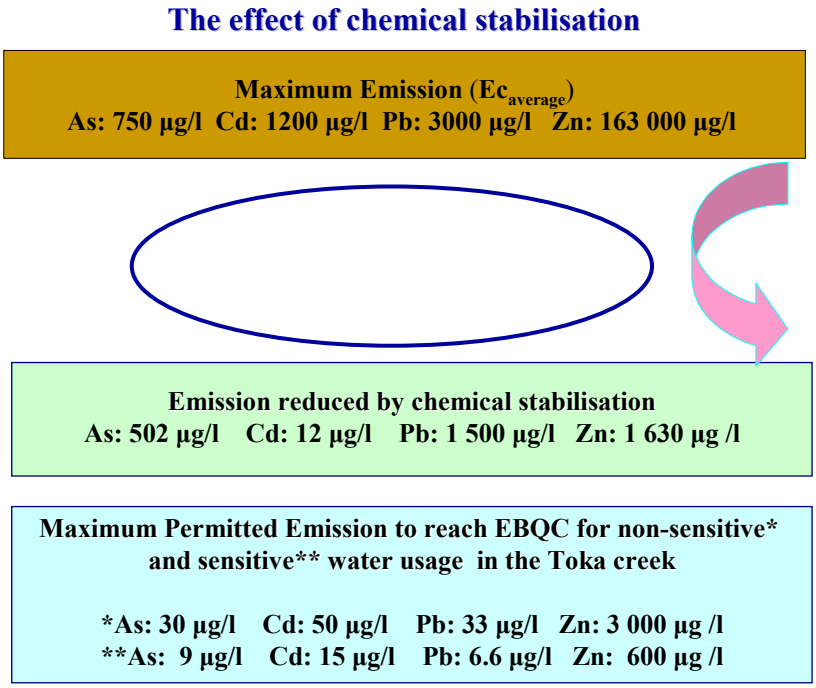

Figure 18. Scheme of calculating the reduced emission from a highly polluted area considering only the effect of chemical stabilisation

The Cd and Zn emission from a highly polluted area could be reduced below the maximum permitted emission (MPE) values for non-sensitive water use and in case of Cd below the sensitive water use when calculating with the maximum efficiency of chemical stabilisation.

The scheme of estimating the effect of chemical stabilisation applied to an area with average emission is shown in Figure 19. below:

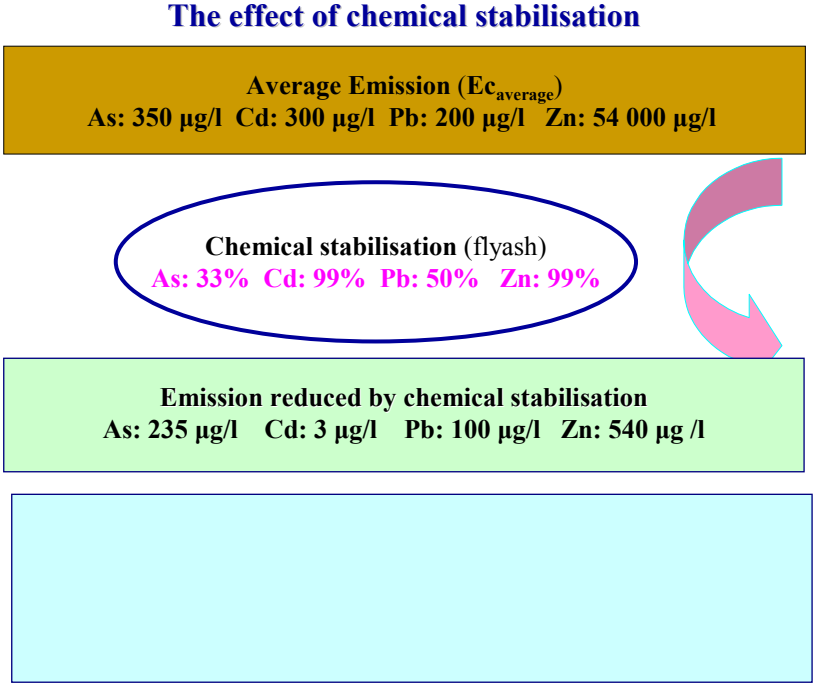

Figure 19. Scheme of calculating the reduced emission from an average polluted area applying only chemical stabilisation

Chemical stabilisation is able to reduce the Cd and Zn emission from an area with average pollution (average emission) well below the maximum permitted emission (MPE) value for sensitive water usage, when calculating with the maximum efficiency of chemical stabilisation.

The As emission is 8 times as much as the requirement for the non sensitive water usage (Figure 19.) and 26 times the requirement for sensitive water usage. The Pb emission is 3 times the requirement for non-sensitive water usage and 15 times the requirement for non-sensitive water usage. Given that As and Pb are transported mainly in the solid phase, the prevention of solid erosion by phytostabilisation will further reduce the As and Pb emission.

Phytostabilisation has to reduce solid transport by erosion from the diffuse pollution sources such as the As and Pb emission is also reduced to the required MPE levels. The required reduction % by phytostabilisation is shown in Figure 18.

Figure 20. shows the Targeted Risk Reduction Efficiency (TRRE) that incorporates the effect of Chemical Stabilisation plus Phytostabilisation and outlines the required risk reduction by phytostabilisation. The efficiency of the chemical stabilisation resulted from the microcosm experiment (Table 15). Even in case of maximum emission, Cd and Zn can be stabilised by chemical stabilisation such as to comply with the MPE requirement for nonsensitive water use. In case of a maximum emission source the required risk reduction by phytostabilisation is 63% of the maximum As emission (750 µg/l) and 49% of the maximum Pb emission (3 000 µg/l) to comply with the quality requirements (EBQC) of the Toka creek in case of non sensitive water use.

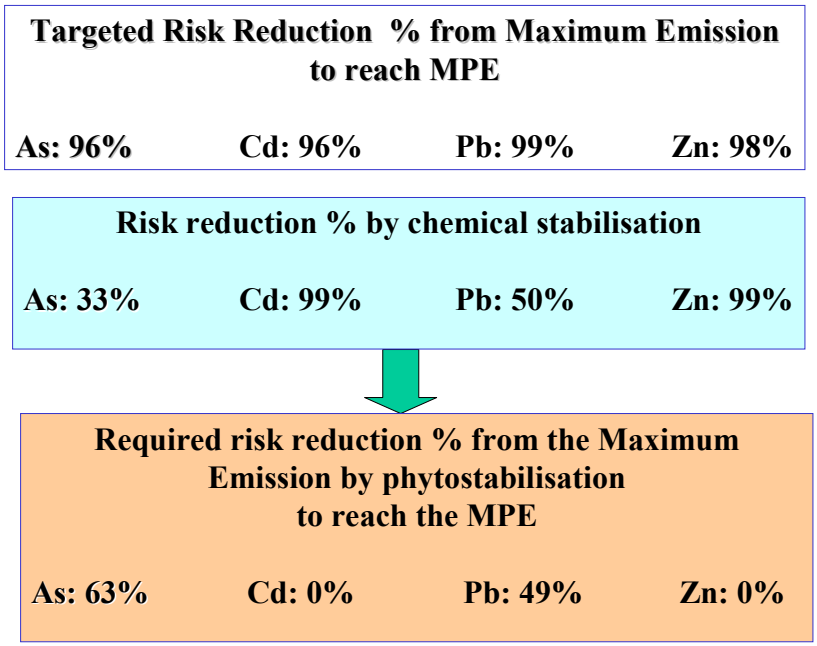

Figure 20. Required Risk reduction % by phytostabilisation in case of maximum emission

The implementation of the chemical+phytoremediation alternative will reduce the emission and pollution load in the surface water flow (surface runoff) of the area, however the subsurface runoff and mine water will have to be treated separately. A water treatment methodology (liming) has been planned for the mine water flow and the alternative of using "Passive treatment systems" was considered. The scheme of calculating the liming or alternative treatment efficiency of mine water based on the Effect-based Quality Criteria for sensitive water usage is shown below (Figure 21.).

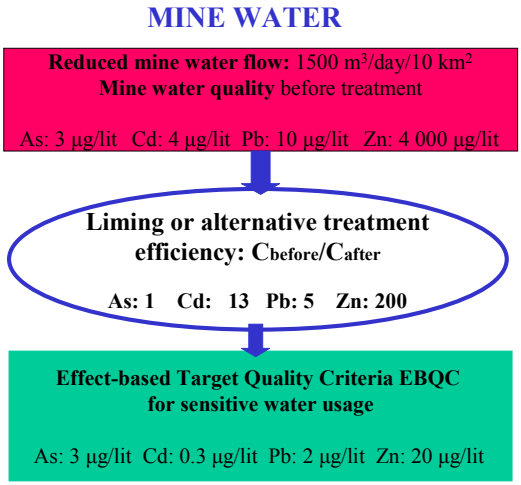

Figure 21. Scheme of calculating the efficiency of liming or alternative treatment

The term “passive treatment system” in the context of mine waters refers to a “water treatment system that utilises naturally available energy sources such as topographical gradient, microbial metabolic energy, photosynthesis and chemical energy and requires regular but infrequent maintenance to operate successfully over its design life” (PIRAMID Consortium 2003). The type of passive system planned to be used would be a mixed compost/limestone system, the so called Reducing and Alkalinity producing System (RAPS) (P. Younger et al., 2002). Choosing of passive treatment technologies is justified by the lower mine water discharge after mine closure and relatively lower contaminant concentrations.

Mine closure and remediation planning in Gyöngyösoroszi started in 2004. It means that all the results of the Project will be used.

Cost estimation

Phytostabilisation combined with chemical stabilisation was tested at laboratory level. Fly ash, lignite and limestone were tested as chemical stabilisers on highly polluted soil from the Gyöngyösoroszi area. Based on the laboratory test results the efficiency of the chemical additives has been compared.

The most efficient combination alternative of chemical and phytostabilisation was used for preliminary cost calculation. The total surface area that remains after removal of the mine wastes was considered for treatment.

Our cost calculation assumed 5 % fly-ash addition to the polluted soil, based on the results of the lab experiment.

The preliminary cost calculation was done based on technology planning that covers 7 years of treatment. During the 0 year, the 1st and 2nd year the total surface area (68 000 m^2) was used for the cost calculation, while starting with the 3rd year till the 7^{th} year the surface area to be treated was reduced to 40 000 m^2, reduced by the less contaminated and already revegetated part. The costs show a decrease during the years according to decreasing treatment and management need.

The preliminary cost calculations resulted the following total costs:

- Total costs of chemical and phytoremediation of the 68 000 m^2 for 7 years is: **76 000 000 HUF (300 000Euros)**
- Unit cost of chemical and phytoremediation for 7 years is: **1 100 HUF/m^2/7 years**
- Average unit cost of chemical and phytoremediation for 1 year is: **157 HUF/m^2/1 year (0,63 Euros/m^2/1 average year)**

The summary of the calculated costs and unit costs/hectare is provided in Table 17.

Table 16. The costs of phytostabilisation combined with chemical stabilisation for 7 years

Costs	HUF/ha	0 year	1 year	2 years	3 year	4 year	5 year	6 year	7 year	Aftercare	TOTAL costs (HUF)
Preliminary experiments (HUF)		17 500 000									**17 500 000**
Treatment by flyash	615 000	4 182 000									**4 182 000**
Autumn stripping	4 500	30 600									**30 600**
Autumn ploughing	6 300	42 840									**42 840**
Levelling	4 500		30 600				18 000				**48 600**
Spring fertilising	10 000		68 000	68 000	40 000	40 000	40 000	40 000	40 000		**336 000**
Preparation of the seed bed	4 000		27 200				16 000				**43 200**
Sowing	4 500		20 025				18 000				**38 025**
Spraying insecticides	2 000		13 600	13 600	8 000	8 000	8 000	8 000	8 000		**67 200**
Watering			344 584	344 584	202 697	202 697	202 697	202 697	202 697		**1 702 653**
Seeds 2 kg/hectar	8 000		54 400				32 000				**86 400**
Hoeing	4 000		27 200	27 200	16 000	16 000	16 000	16 000	16 000		**134 400**
Management, organisation, protection		3 720 000	3 720 000	3 720 000	3 720 000	3 720 000	3 720 000	3 720 000	3 720 000	3 720 000	**33 480 000**
Monitoring			900 000	3 600 000	720 000	720 000	720 000	450 000	1 800 000	380 000	**9 290 000**
Risk communication		1 626 000	1 626 000	1 626 000			1 626 000			1 626 000	**8 130 000**
		27 101 440	**6 831 609**	**9 399 384**	**4 706 697**	**4 706 697**	**6 416 697**	**4 436 697**	**5 786 697**	**5 726 000**	**75 079 918**

A comparison between the costs of four remediation alternatives considered for the Gyöngyösoroszi diffuse pollution has been done to substantiate cost efficiency of the chemical and phytoremediation option (Table 17.)

1. **„0”** alternative: there will be no remediation done, however monitoring and control is needed.
2. **„FS”** alternative: Phytostabilisation and chemical stabilisation (costs detailed in Table 16.)
3. **„RR”** alternative**:** Removal and replacement of the polluted material: “RR”a alternative includes excavation and removal of the total mine waste and its transport to the top of the tailings dump in Gyöngyösoroszi and transport to the site of the unpolluted borrow material. “RR”b includes excavation and removal of the polluted material and its transport to a hazardous waste storage facility and its final placement. The cost of transport of the polluted material to the hazardous waste disposal site and its final placement onto the hazardous waste storage site is 5 fold the cost of the RRa. option.

Table 17. Comparison of the costs of four remediation alternatives

COSTS (HUF)	„0”	”FS”	“RR” a	“RR” b
Excavation of the polluted material			42 600 000	42 600 000
Transport of the polluted material to tailings dump			42 600 000	
Transport of the polluted material to waste storage facility				128 000 000
Final placement of the excavated polluted material				1 280 000 000
Preliminary experiments		17 500 000		
Agro-technical works and chemical stabilisation		6 679 918		
Unpolluted borrow material and its transport			256 000 000	256 000 000
Management, organisation, protection	15 679 285	33 480 000	15 000 000	15 000 000
Monitoring	3 085 500	9 290 000		
Risk communication	5 420 000	8 130 000		
TOTAL (HUF/7 years)	24 184 785	76 000 000	356 200 000	1 721 600 000
TOTAL (EURO/7 years)	96 740	300 000	1 424 800	6 886 400

As most of the wastes and polluted material will be removed from the site, thanks to the decision on the realisation of the final mine closure and complete remediation, 68 000 m^2 polluted surface is considered as diffuse pollution source and is included into the Difpolmine remediation plan and cost evaluation.

The total cost of the chemical and phytoremediation alternative planned for 7 years is threefold the price of the “0” option (no remediation), which still involves management, organisation, monitoring, protection and risk communication.

Conclusions and the potential adaptation and eventual modification of the approach applied to the Toka water catchment

One of the aims of the Difpolmine project was to demonstrate the adaptation potential of the Difpolmine approach applied to diffuse pollution of mining origin at the Salsigne site.

The adaptation of a GIS based concept and risk based remediation approach using combined chemical and phytoremediation were to be implemented on the Hungarian demonstration site.

The approach adapted to the Hungarian demonstration site was a catchment scale and GIS based concept taking into account the actual status of the site and the site-specific characteristics and parameters.

Due to the status of the Hungarian site at the start of the Project the Hungarian methodology contains also the stages prior to the treatment of the diffuse pollution: mine closure, assessment of pollution and pollution sources, differentiation between point and diffuse sources according to a tiered risk assessment methodology, and risk reduction of the point and diffuse sources according to their actual and targeted emission.

The concept is based on an integrated conceptual risk model that shows the sources and the pollutant transport pathways, the exposure pathways of the receptors function of the land use.

The methodology was worked out on catchment scale basis. Starting from the watershed of the sources, the methodology is adaptable to any diffuse pollution area and water sub-catchment, where the dominant risk is the runoff and surface water transported metal load. (Zn, Cd).

The risk characterisation methodology includes:

a) Qualitative Risk Assessment based on a score-system for initial hazard identification and rough ranking, allowing for priority setting and differentiation between point and diffuse/residual sources

b) GIS-based Quantitative Hazard Assessment (Generic Risk) that results the quantitative emission of the sources with the help of the GIS based Flow Accumulation and Transport Model. The GIS based Quantitative Hazard Assessment can be applied individually to each pollution source, sub-area, and total water catchment.

The hazard is assessed by quantitative characterisation of the emission from the sources. The quantitative emission data are used for refined ranking, more precise differentiation between point and diffuse sources and estimation of the metal load at catchment scale. When defining the quantitative hazard based on the metal emission, the maximum value of the emission was taken into account in light of a pessimistic approach. Total emission, and consequently the water transported metal load will decrease in time exponentially. The initial phase of this process (the highest risk period) was studied and all the calculations were based on it in our pessimistic model.

c) According to the site specific Quantitative Risk Assessment of the Toka catchment area the risk quotient (RQ=PEC/PNEC) is higher than 1 (RQ>1). The target risk value is RQ =1. The PEC is given by the measured metal concentrations of the Toka creek water and sediment. The PNEC is defined based on effect based quality criteria obtained from literature and regulatory data. The aim is to reduce PEC to the PNEC value.

After determining the target concentration in the Toka water, the Maximum Permitted Emission was calculated by using the risk based, catchment scale transport model.

In order that the risk characterisation approach could be adapted, it has to be site-specific, taking into account the Water Balance of the area, developed based on meteorological data, geology, leaching parameters, natural risk reduction capacity of the site and the targeted Effect based Quality Criteria for surface water. The site-specific GIS based quantitative risk assessment enables planning of risk reduction, calculation of the expected result of the risk reduction measures.

Within the three tiered iterative Risk Assessment process the Quantitative Hazard and Quantitative Risk were calculated only based on the metal transport by runoff and surface water. The solid phase transport by water was not modelled separately. However the PEC value from our Quantitative Risk Assessment incorporates the risk posed by the water-transported sediment too. The Risk Assessment currently is being refined, by adding Erosion Modelling to it, enabling us to have the solids transport considered separately in the approach. Given that erosion modelling is in progress and the model has not been yet validated, this report does not include any of the results

The planned risk reduction is combined chemical and phytoremediation. It is applicable to diffusely polluted and residual pollution areas after removal of point sources. The expected risk reduction scale can be planned using the target water quality of the surface water and target emission of the polluted area before application of the risk reduction measures. The effect of the removal and non-removal of any point or diffuse source can be also calculated. The efficiency of chemical and phytoremediation (based on microcosm experiments) is used to calculate the necessary emission control from the polluted area, taking into consideration the Effect Based Quality criteria set for the surface water.

Acknowledgement

In addition to the financial support of the “DIFPOLMINE” (EU LIFE/02/F/000291) demonstration project, part of the research work presented in this report was supported by the “BANYAREM” Hungarian R&D project (GVOP/-3.1.1-2004-05-0261/3.0) and the “MOKKA” Hungarian R&D project (NKFP3-020-05).

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Dissemination

Dissemination has been done via three main lines: Knowledge transfer by Mainstream University Education, Conference/Training Course/Workshop and Publications.

Mainstream University Education

The results of the Difpolmine project and the methodology worked out within it have been integrated into the mainstream university education, namely in the Risk Management of Contaminated Sites chapter of the Soil Remediation subject.

The outcome of knowledge transfer via University Education subjects: are: Diplomaworks, Ph.D thesis and Publications

Diplomaworks have been completed and a Ph.D thesis is in progress on the risk assessment, risk management tools dealing with in the Hungarian demonstration site of the Difpolmine project.

Diplomaworks:

Szabó, J.: Risk assessment of acidic waste rock drainage in the region of Gyöngyösoroszi, 2003

Auerbach, R.: Bioaccumulation of toxic metals in vegetable species grown on Gyöngyösoroszi garden soil, 2003

Feigl, V.: Integrated methodology to monitor the efficiency of various chemical stabilisers applied to toxic metal contaminated soil in microcosm experiments, 2005

Ph.D. thesis:

Sipter, E.: Health risk of toxic metal pollution (in progress)

Conference/Training Course/Workshop

Difpolmine Training Course and Conference 2005

Organisation of a Difpolmine Training Course and Conference 2005 in Hungary was an initiative within the DIFPOLMINE (Diffuse Pollution from Mining Activities) project funded by the Life Environment Programme of the European Commission and had the aim to disseminate the results and experience of the "Difpolmine methodology" applied in Salsigne France and demonstrate its applicability in a former lead zinc mining area, Gyöngyösoroszi, Hungary.

The Difpolmine Training Course and Conference 2005 in Budapest was organised by the Environmental Microbiology and Biotechnology Group of the Budapest University of Technology and Economics on 4-8 July 2005 in collaboration with the Hungarian Chemical Society and the support of the Public Foundation for the Progress of Industry in Hungary and the French Institute in Budapest.

The webpage of the event: http://envirobiotech.mkt.bme.hu/conference.htm

Topics:

- Site-specific risk assessment,
- Fate and nature of toxic metals in the environment
- GIS based pollution transport modelling
- Remediation of toxic metal polluted sites
- Legislation and regulation
- Management of sites with diffuse pollution
- Monitoring of toxic metal polluted sites
- Site specific pollution transport: Salsigne and Gyöngyösoroszi
- Reduction of pollutant transport: Salsigne and Gyöngyösoroszi

Dissemination ways:

- Webpage: http://envirobiotech.mkt.bme.hu/conference.htm
- Included in the programme of the French Institute in Budapest
- Included in the programme of the Hungarian Soils Science Society, Group of Soils Pollution
- CD with the Proceedings of the Difpolmine Training Course and Conference 2005 Budapest distributed to all participants
- Announced in the Newsletter of the Hungarian Environmental Enterprises
- Announced in the Newsletter of the Hungarian Chemical Society

Participants:

- The Difpolmine Training Course involved 34 participants: 15 invited lecturers and 19 young scientists, researchers, students
- The Difpolmine Conference had almost 60 participants and 10 invited speakers

Benefits:

- it gave an overview on the risk management of point and diffuse pollution sources originated from mining industry.
- it summarised the results and the efforts invested in the project work for the adaptation and modification of the Difpolmine methodology in Hungary, Gyöngyösoroszi.
- it showed that the results of the Difpolmine project will be used within the mine closure and remediation of the Gyöngyösoroszi mining area, started already in 2003 in the frame of the Hungarian National Remediation Plan.
- the event brought together not only the leading scientists of the DIFPOLMINE project, but also invited experts from all over Europe specialised in the management of toxic metal pollution, polluted sites stakeholders, polluted sites remediation and revegetation specialised companies, junior researchers, students.
- it covered several interdisciplinary fields able to support risk management of point and diffuse pollution sources
- it disseminated the results of the DIFPOLMINE project and demonstrated the adaptation to the Hungarian site of the methodology applied in Salsigne France

9th International FZK/TNO Conference on Soil-Water Systems, CONSOIL 2005, Bordeaux 3–7 October 2005

Lecturing at the CONSOIL 2005 Conference, lecture Session F.1.: Mining and related cases, about the adaptation of the Difpolmine methodology to the Hungarian demonstration site, Gyöngyösoroszi and Poster Presentation in Theme C.

Abstract of the presentations was included in the CONSOIL 2005 Abstract Book of Presentations:

Gruiz, K.; Vaszita, E.; Siki, Z.: Environmental Risk Management of Mining Sites with Diffuse Pollution – In: Abstracts of presentations of the 9th International FZK/TNO Conference on Soil-Water Systems, 3–7 October, 2005, Bordeaux, pp.183–184, 2005

The full papers are on the CD of the Conference Proceedings:

Gruiz, K.; Vaszita, E.; Siki, Z.: Environmental Risk Management of Mining Sites with Diffuse Pollution – In: Conference Proceedings, CD (9th International FZK/TNO Conference on Soil_Water Systems, 3–7 October, 2005, Bordeaux) Theme F, pp. 2568–2574 , Eds. O. Uhlmann, G.J. Annokkée, F. Arendt, 2005

Sipter, E.; Auerbach, R.; Gruiz, K.; Máthé-Gáspár, G.: Bioaccumulation of toxic metals in vegetable species: Pot experiment – In: Conference Proceedings, CD (9th International FZK/TNO Conference on Soil_Water Systems, 3–7 October, 2005, Bordeaux) Theme C, pp. 1331–1336, Eds. O. Uhlmann, G.J. Annokkée, F. Arendt, 2005

Workshop launched by the PECOMINE 2. on „Methodological baselines and pilot studies for risk based inventories of mining sites" in Krakow, between 24-25 November 2005, organised by the EC JRC DG Institute for Environment and Sustainability

The debate of the proposed Mining Waste Directive in the EP and the Council reached its final phase and the Directive is likely to enter into force in 2006. This will require the Commission and Member States to come up with commonly accepted methodologies for risk based assessment and inventories of waste materials from mineral extraction, not only for active mining sites but also for historical mining regions, which are widespread across the territories of most Member States and Candidate Countries.

The workshop intended to shape a new programme, opening the discussion and set-up a network of pilot sites for developing the methodological baselines for risk based inventories of waste material from mining extraction across Europe.

The invitees were solicited to inform about the activities in their countries and jointly review complementarities of the chosen methodologies and approaches.

Abstract of the presentation was included in the Abstract Book of Presentations:

Gruiz, K.: Risk assessment and management of mining related diffuse and point pollution at catchment scale – In: Abstracts of presentations of PECOMINE 2. workshop on „Methodological baselines and pilot studies for risk based inventories of mining sites" Krakow, 24-25 November 2005, EC JRC DG Institute for Environment and Sustainability, 2005

Publications on topics connected to the Gyöngyösoroszi demonstration site: 2003-2005

Gruiz, K.: Interactive Ecotoxicity Tests for Contaminated Soil – In: Wissenschaftliche Berichte, Consoil 2003, pp. 267-275, CA 141:394830, 2003

Sipter, E.; Menczel, I. and Gruiz, K.: Methods for the site specific human health risk assessment of toxic metals containing cultivated plants – In: Abstracts of Presentations of the 8th International FZK/TNO Conference on Contaminated Soil (12–16 May, 2003, Gent) p. 165, 2003

Sipter, E.; Menczel, I. and Gruiz, K.: Methods for the site specific human health risk assessment of toxic metals containing cultivated plants – In: Conference Proceedings, CD (8th International FZK/TNO Conference on Contaminated Soil, 12–16 May, 2003, Gent) Theme F, pp. 3401–3408, 2003

Sipter, E.; Auerbach, R.; Gruiz, K.; Máthé-Gáspár, G.: Bioaccumulation of toxic metals in vegetable species: Pot experiment – In: Conference Proceedings, CD (9th International FZK/TNO Conference on Soil_Water Systems, 3-7 October, 2005, Bordeaux) Theme C, pp. 1331–1336, Eds. O. Uhlmann, G.J. Annokkée, F. Arendt, 2005

Gruiz, K.; Vaszita, E.; Siki, Z.: Environmental Risk Management of Mining Sites with Diffuse Pollution – In: Abstracts of presentations of the 9th International FZK/TNO Conference on Soil-Water Systems, 3-7 October, 2005, Bordeaux, pp.183-184, 2005

Gruiz, K.; Vaszita, E.; Siki, Z.: Environmental Risk Management of Mining Sites with Diffuse Pollution – In: Conference Proceedings, CD (9th International FZK/TNO Conference on Soil_Water Systems, 3-7 October, 2005, Bordeaux) Theme F, pp. 2568–2574 , Eds. O. Uhlmann, G.J. Annokkée, F. Arendt, 2005

Gruiz, K.: Risk assessment and management of mining related diffuse and point pollution at catchment scale – In: Abstracts of presentations of PECOMINE 2. workshop on „Methodological baselines and pilot studies for risk based inventories of mining sites" Krakow, 24-25 November 2005, EC JRC DG Institute for Environment and Sustainability, 2005

Leitgib, L.; Kálmán, J.; Gruiz, K.: Comparison of bioassays by testing whole soil and their water extract from contaminated sites – sent to Chemosphere for review, 2005

Sipter, E.; Rózsa, E., Gruiz, K.: Risk Assessment and mapping of a toxic metal polluted site – will be sent to The Science of the Total Environment for review, 2005