Scoring based Risk Assessment in an abandoned base metal sulphide mining area

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Introduction

To characterise the environmental risk of the Gyöngyösoroszi abandoned base metal mining site in Hungary a tiered, iterative risk assessment methodology was developed and applied at catchment scale.

The methodology includes: 1) a Preliminary Qualitative Risk Assessment to produce an inventory of the pollution sources, 2) a scoring based Semi-Quantitative Risk Assessment tool for initial hazard identification and rough ranking, 3) a GIS (Geographical Information System)-based Quantitative Hazard Assessment tool for refined ranking with the quantification of the hazard based on the emission 4) a site-specific Quantitative Risk Assessment tool for the calculation of the necessary Risk Reduction by remediation.

The site specific scoring based Semi-Quantitative Risk Assessment and its implementation and results is introduced here.

Aim

- to compare and set a priority amongst the point and diffuse sources.
- to support environment- and cost-efficient decision-making and the risk-management strategy in the course of the complex rehabilitation of the site.

Method

Additive numerical method, assigning scores to a number of site characteristics or factors relevant to the **sources**, **transport routes**, target environmental compartments and the **receptor** ecosystems and humans.

In deriving the scores the recommendations of the National Classification System for Contaminated Sites (NCSCS) of the Canadian Council of Ministers of the Environment (CCME 1992) were taken into account.

Source/contaminant, **transport pathway**, **receptors** characteristics were considered to be of equal importance under the scoring system, and were weighted equally (33, 33, and 34 points, respectively).

Score summary

Source characteristics	Score	Transport Pathways	Score	Receptors	Score
Waste quantity		Surface water		Environmental compartments	
Contaminant concentration		Ground water		Humans	
Contaminant physical-chemical properties		Direct contact Direct transport		Ecosystem	
Other factors		Other factors		Other factors	
TOTAL SCORE Maximum 33		**TOTAL SCORE** Maximum 33		**TOTAL SCORE** Maximum 34	
TOTAL SCORE FOR SITE		**SITE NAME**			
Action to be taken:					

Examples of scales of scoring

Scale for scoring the type of contaminant and estimated concentration

Hungarian soil quality criteria (B_{soil})	Score
B_{soil} is exceeded by 1 metal	1
B_{soil} is exceeded by 2 metals	2
B_{soil} is exceeded by more metals	5
$2xB_{soil}$ is exceeded by 1 metal	6
$2xB_{soil}$ is exceeded by 2 metals	7
$2xB_{soil}$ is exceeded by more metals	8
$5xB_{soil}$ is exceeded by 1 metal	9
$5xB_{soil}$ is exceeded by 2 metals	10
$5xB_{soil}$ is exceeded by more metals	11
$10xB_{soil}$ is exceeded by 1 metal	12
$10xB_{soil}$ is exceeded by 2 metals	13
$10xB_{soil}$ is exceeded by more metals	14

Scale for scoring the metal contamination of ground water

Hungarian ground water Quality Criteria (B_{gw})	Score
Drinking water quality	0
B_{gw} exceeded by 1 metal	1
B_{gw} exceeded by 2 metals	2
B_{gw} exceeded by 3 or more metal	4
2x B_{gw} exceeded by 1 metal	5
2x B_{gw} exceeded by 2 metals	6
2x B_{gw} exceeded by 3 metals	7
3x B_{gw} exceeded by 1 metal	8
3x B_{gw} exceeded by 2 metal	9
3x B_{gw} exceeded by 3 metal	10
More x B_{gw} exceeded by more metals	11

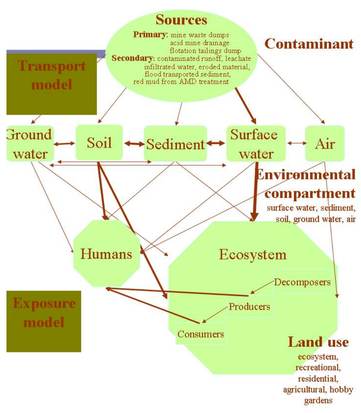
Scale for scoring the waste quantity

Tonnage (t)	Scores
≤10	2
10–100	3
101–1000	4
1001–10 000	6
10 001–100 000	8
100 001–1 000 000	9
>1 000 000	10

Scoring guidelines for adverse effects on environmental receptors

Adverse effects on sensitive ecological area	Score
Strongly suspected adverse effect on sensitive ecological area	12
Confirmed stress on water or/and terrestrial ecosystem in the vicinity of the pollution source	14
Confirmed adverse effects on sensitive ecologic area	16

Integrated Risk Model of the Gyöngyösoroszi site



*The developed site specific scoring based Risk Assessment system creates/derives the scores from measured/estimated quantitative characteristics selected based on the **Integrated Risk Model** of the site including **source/contaminant, transport pathways and receptors.***

*The main pollution sources, the **mine waste dumps** incorporate waste rocks from historical mine workings, ore fragments lost during haulage by mine cars. The photo shows the result of a site specific process, the bioleaching of pyrite containing mine waste exposed to air and in contact with runoff.*

Eroded mine waste dump and acid rock drainage

Results

A number of 34 pollution were assessed and classified according to the assigned scores in terms of the actions to be taken: to be remediated, to be treated as diffuse pollution source, detailed assessment is needed or to be excluded from further assessment and remediation:

A: 71–100 points: very high risk – Action: remediation

B: 55–70 points: high risk – Action: refined risk assessment and remediation is necessary.

C: 40–54 points low and very low risk – Action: after refined risk assessment probably other action than revegetation is not likely to be required.

D: <40 points: no risk – Remedial action other than revegetation not needed.

Ranking of the pollution sources according to the total score and the required action

Crt. No.	Name of the source	Assigned scores			Total score	Action decided
		Source	Transport	Receptor		
1	Flotation tailings pond	33	29,5/30	34	99	**A** Action required typically resulting from an immediate risk to human health and/or the environment or *insufficient data, more information needs to be collated*
2	**Industrial reservoir sediment**	31	25,8/31	31	93	
3	*Ore transportation route*	31	27	34	92	
4	**Lime precipitate settling ponds**	32	27,8	31	90,8	
5	Agricultural reservoir sediment	31	26,8	31	88,8	
6	Mátraszentimre mine waste dump I	31	25,5	31	87,5	
7	Mátraszentimre mine waste dump II	29/31	26,5	31	87,5	
8	**Mud retention dam**				85,5	
9	Altaro mine waste dump	29	24,5	31	84,5	
10	Károly adit mine waste dump	27	27,5	27	81,5	
11	Bányabérci mine waste dump				81,5	
12	Gyöngyösi reservoir sediment	29	25,3	27	81,3	
13	Toka Creek sediment				>80	
14	Új Károly-adit mine waste dump I.				79,5	
15	Új Károly-adit mine waste dump II				79,5	
16	**Flotation plant emergency pond**	29	20,3	29	78,3	
17	Péter-Pál shaft waste dump	24	22,8	29	75,8	
18	*Katalin adit waste dump*	19	27,5	27	73,5	
19	*Nagytölgy+István waste dump*	23	22,5	27	72,5	
20	Péter-Pál adit dump	21	23,5	29	64,2	**B** Action likely required. Sources to be treated as diffuse pollution Probabaly in situ remediation
21	Ezüstbányabérc dump	21	21,8	20	62,8	
22	Kistölgyesi adit waste dump I	23	19,8	18,2	61	
23	Szákacsurgó waste dump	21	20	18,7	59,7	
24	Pelyhes adit waste dump I.	21	20	18,7	59,7	
25	Hideg-kúti adit waste dump	15	22,5	18,8	56,3	
26	Vereskői adit waste dump	15	20	19,7	54,7	**C** Action other than revegetation not likely to be required
27	Kistölgyesi adit waste dump II	14	21,5	18,2	53,7	
28	Vizeslyuk waste dump	20	16,3	12	48,3	
29	József adit waste dump	12	18,3	17,7	48	
30	Lajos adit waste dump				<40	**D** No other action than revegetation is needed.
31	Lujza adit waste dump				<40	
32	Aranybányabérci waste dump				<40	
33	Bányabérci gallery waste dump				<40	
34	Pelyhes adit waste dump II.				<40	

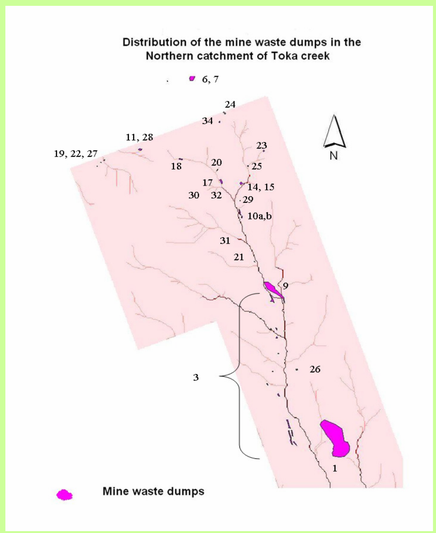
*The assessment includes also other pollution sources than mine waste dumps such as flotation tailings, **lime precipitate from acid mine water treatment**, and polluted sediments*

Lime precipitate from acid mine water treatment before remediation

The lime precipitate storage pond during remediation

*Excavation of the red mud (**lime precipitate**) from **acid mine water treatment**. The work is part of the remediation plan. This pollution source has been classified within the scoring based Risk Assessment as high priority source resulting from immediate risk to human health and the environment.*

*This Figure shows the location of the 34 **pollution sources** in the Toka catchment. The pollution sources are numbered from 1 to 34 in the order of the hazard assigned by the Scoring based Risk Assessment. The sources are visualised on the Flow Accumulation map of the Toka water catchment.*



Location of the pollution sources

Conclusion

The results:

- expressed the relative risk associated with the identified pollution sources,
- documented the evaluation and decision making process of the mine closure and remediation plan in the area and
- were used to select the high priority areas where contaminant release may result significant risks.

Firm conclusions about the need for remedial action was still dependent on the results of the quantitative hazard assessment and other factors such as local issues, availability of technology, remediation costs, planned long-term use of the site, etc .

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