Strengthening capacities in the Western Balkans countries to address environmental problems through remediation of high priority hot spots:

Montenegro country component- Mojkovac Lead and Zinc Tailing Mine Impound

Montenegro, 06-07, May 2009

Milica Begović Radojevic
Ana Daković
Borko Vulikić

United Nations Development Programme

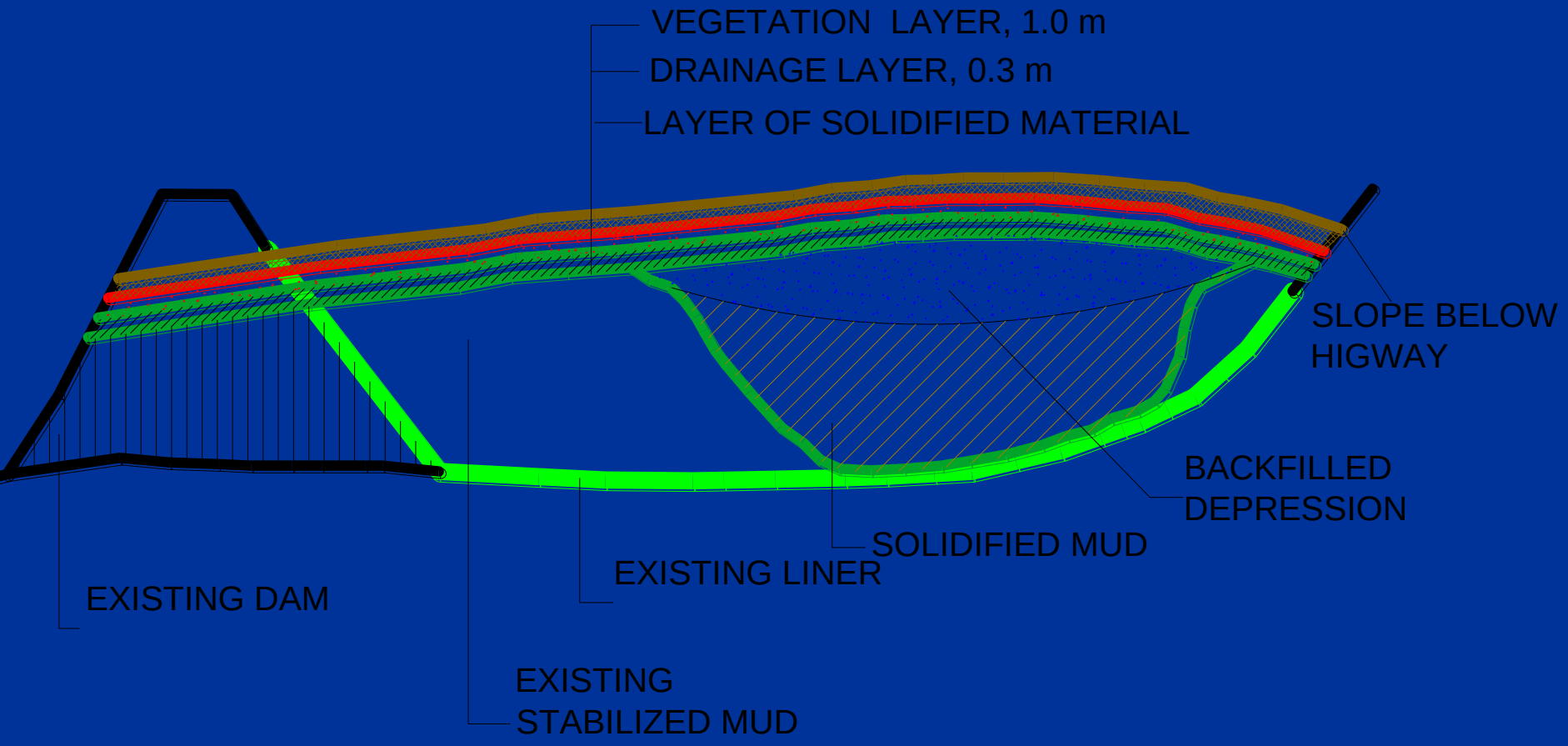

Mojkovac
Mojkovac, Crna Gora, Montenegro

Western Balkans Environmental Programme

Koninkrijk der Nederlanden

UNDP

United Nations Development Programme



United Nations Development Programme

Risks and problem:

- risk of eventual breakdown of dam stability, that could cause taking off the impounded material from TMI into Tara River,

- leaching of muddy and liquid component of the impounded material through bottom and lateral sides of Tailing Mine Impoundment and disposing the latter in Tara River,

- discharge into TI and accumulation of non treated waste waters of Mojkovac, and direct or indirect runoff into Tara River,

United Nations Development Programme

- accumulation in Tailing Mine Impoundment of surface waters from the urban area of Mojkovac and from the road Kolasin-Mojkovac-Bijelo Polje and leaching of the latter through deposited material with a possibility of final discharge into Tara River,

- deposing of municipal solid waste at Tailing Mine Impoundment,

United Nations Development Programme

First steps in solving these problems:

2003 - Technical Design Project for tailings impoundment remediation and recultivation

- Faculty of Civil Engineering, Podgorica was selected and contracted to prepare Technical Design Project named “Remediation and recultivation of the Mojkovac lead and zinc TMI”

United Nations Development Programme

Project solution of protection of inflow of outer surface stormwaters from the highway and belonging direct pouring into the tailings impoundment area .

Project solution of remediation of sewage for used waste waters of the town of Mojkovac

Project solution of eliminating present water from the tailings impoundment

Project solution of filling and final treatment of the flotation tailings impoundment dump

Project solution of the exploatation of the material for backfill

Project solution of the watering system of the tailings impoundment area

United Nations Development Programme

Stability monitoring of the taillings impoundment

Western Balkans Environmental Programme

Koninkrijk der Nederlanden

UNDP

Surveying basis
Geological work
Hydrological and climate basis
Testing of the quality of water and sediments
Testing of water contents and deposited material in the tailings impoundment
Testing of characteristics of the material which will be used for cover layer

United Nations Development Programme

The impoundment according to previous reports contains:

lead 20%; zinc 0,3%; Cu 0,1%, Iron 4-5%; , sulphur 10-12%,

and other heavy metals like antimony, quicksilver, arsenic, cadmium, silver, gold, manganese, titanium, molybdenum but in much lower concentrations.

- pH 10-12 very alcaline
- contained cyanides and phenol materials.

1. Testing of the quality of water and sediments

2. Testing of water contents and deposited material in the tailings impoundment

Research performed by -- CETR

United Nations Development Programme

TYPE OF ACTIVITY	*Unit of measurement*	*Ammount planned*	*Ammount accomplished*
5.0 TESTING OF QUALITY OF WATER AND SEDIMENTS 5.1.1 Studying and processing of recent data and working out of the final elaboration	days	60	60
5.1.2 QUALITY OF SURFACE WATERS AND SEDIMENTS •Sampling, physical, chemical and physico-chemical, microbiological and radiological analyses •Analysis of surface waters •Analyses of sediments	sample	11 11 11	10 10 10
5.1.3 QUALITY OF WATERS IN PIEZOMETRS	sample	6	4
5.1.4 QUALITY OF ACCUMULATED WATER IN THE TAILINGS IMPOUNDMENT	sample	3	8
5.1.5. 5 QUALITY OF THE DEPOSITED MATERIAL IN THE TAILINGS IMPOUNDMENT •Physico-chemical analysis •Granulometrici content •2 bores towards the hotel •radioactivity of the sludge	sample	15 15 15 2 1	29 29 29 3 2
5.1.6. ACTING OF DEPOSITED SLUDGE DURING CHANGES OF Ph VALURESi	sample	6	30
5.1.7. RARE ELEMENTS IN THE TAILING	sample	6	18
5.2. QUALITY OF CHANNELED WASTE WATERS	sample	2	4
5.3 CHARACTERISTICS OF COVERING MATERIAL	Sample	10	2

Water analysis cover the following tracer parameters:
pH, conductivity, HPK, Cl, SO_4, H_2S, CN, phenols, oil derivates ,heavy metals, PAH-s, PCB-s, GCMS-SCAN method.

Analyses are executed in compliance with the Decision about the classification and catogorization of waters (''Official gazette of the Republic of Montenegro'', number 14/96) for given A_1, S, I class

United Nations Development Programme

Testing of surface water quality

-Testing area
Three places in the tailings impoundment, two on the edge of the tailings impoundment (nothern and southern side next to the sewage inflow).

- Parameters covered by analyses
Analysis is to be done in compliance with the Decision on the classification and categorization of waters (''Official gazette of the Republic of Montenegro '', number 14/96) for given A_1 S, I class . Analysis of unknown sample is also to be done by GCMS-SCAN method.

Testing of the contents of deposited material in the tailings impoundment

Analyse physical, chemical, physico-chemical characteristics of the deposited material, as well as the contents of the toxic materials on the places where borings should be done (bores should cover all the tailings impoundment area by the depth of boring).

Find percentage and granulometric characteristics of $Si0_2$ in the deposited material.

Parameter	The Rudnica before the Tara		The Tara after inflow of the Rudnice		Water from the tailings impoundment	
	1990	2004	1990	2004	1990	2004
PH	7,3	7,71	8,03	7,99	9,0	6,4-7,2
El. conductivity µS/cm	560	527	191	184	1444	191-229
HPK O_2 mg/l	9,8	0,38	1,3	0.00	160	2,03-124,9
SO_4 mg/l	238	144,0	9,8	8,76	300	11,2-16,4
Cu mg/l	0,254	0,13	0,003	0,01	0,012	0,02-0,04
Zn mg/l	3,6	2,8	0,022	0,04	0,033	0,02-4,5
Pb mg/l	0,854	0,016	0,005	0,000	0,010	0,01-0,193
Cd mg/l	0,011	0,01	0,002	0,000	0,002	<0,001
Hg mg/l	0,005	0,008	<0,005	0,004	0,005	<0001
Ni mg/l	0,33	0,000	<0,005	0,000	0,05	<0,005
As mg/l	4,43	0,000	<0,005	0,000	0,008	0,01-0,03
Fenoli mg/l	0,003	0,03	0,000	0,000	0,05	0,001-0.003
CN mg/l	0,050	<0,005	0,000	<0,005	0,10	0,006-0,029

The biggest pollutant of the river Tara is the Rudnica river

The analysis of the Tare sediments downstream from the tailings impoundment suggests that there are no effects of the tailings impoundment on the river Tara water qualit

Water quality in piezometers outside the tailings impoundment towards the river Tara shows that there is no water percolation from the tailings impoundment outside the dam and there is no influence on the river Tara and the environment

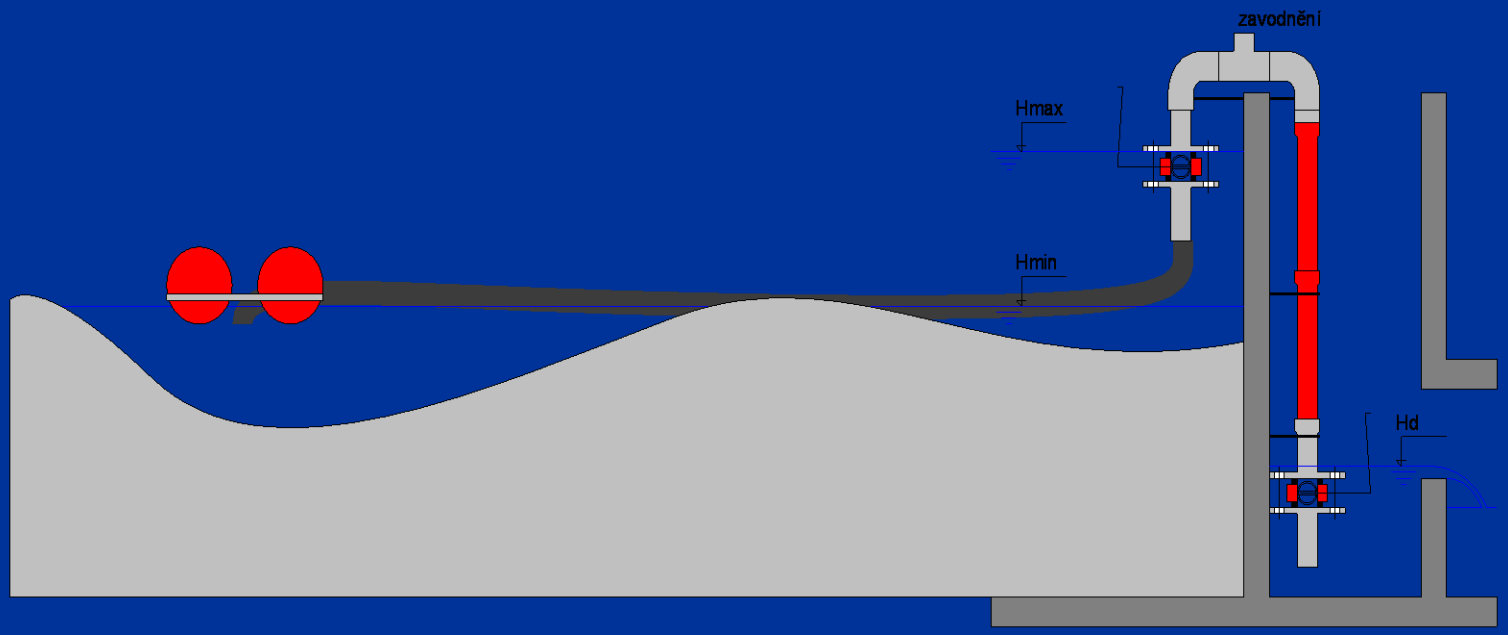
United Nations Development Programme

At this moment the focus of civil works is on solidification process. In order to achieve enabling work environment it was necessary to perform controlled discharge of TMI surface waters.

This was done under supervision and control of Vodni Zdrovje company.

United Nations Development Programme

For discharge of waters floating system bases o flexible pipeline system was created (using existing shaft).



United Nations Development Programme

Quality of discharged water was monitored:

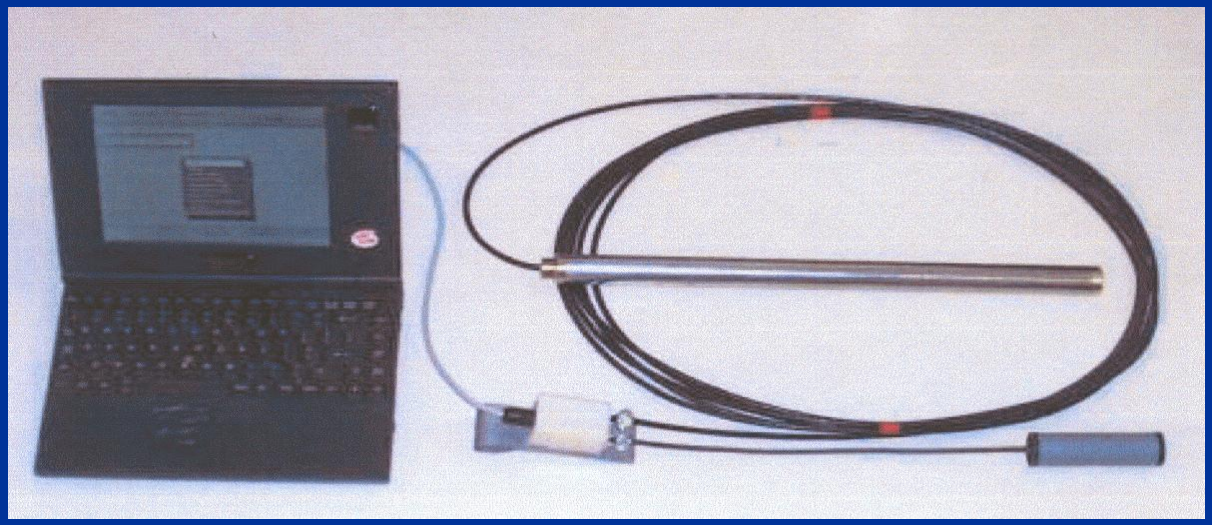
- In continuity (using electrodes for pH, conductivity, temperature of discharged water)
- Periodically (daily, using semi quantitative methods, parameter NH4, NO2, CN, Zn)
- Laboratory analysis (once in two weeks. NH4, NO2, Pb, CN, Zn, ChSK-Cr analysis)

For purposes of measurement in pump station it was installed LGR equipment.

United Nations Development Programme

- For discharge of water quality measurement three measurement units where installed:

- 1 measuring – flow, level and temperature
- 2 measuring – pH values
- 3 measuring – conductivity



United Nations Development Programme