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THE INFLUENCE OF SLAG AND ASH DEPOSIT USED BY DROBETA - TURNU SEVERIN POWER PLANT CONCERNING GROUNDWATER IN THE AREA

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Abstract

The evacuation of slag and ash resulting from coal combustion in Drobeta-Turnu Severin Power Plant is made hydro-mechanical (pumped) in a deposit located near Halanga locality from county Mehedinti. This work shows the hydraulic circuit inside of Drobeta-Turnu Severin Power Plant and the deposit of slag and ash from Halanga. The deposit impact is analyzed concerning groundwater in the area. Also it is presented the waste disposal technology after the date of 31.12.2015, possibly to be used, in order to comply with the European Union Directive 1993/31/CE.

Key words: *coal combustion, groundwater, Power Plant, slag and ash.*

INTRODUCTION

This work shows the hydraulic circuit inside of Drobeta-Turnu Severin Power Plant and the deposit of slag and ash from Halanga. The deposit impact is analyzed concerning groundwater in the area.

During the process of joining to the European Union, Romania has completed negotiations for "Chapter 14 - Energy" and "Chapter 22 - Environment".

For this purpose Romania had to implement EU directives on waste disposal, concerning the limitation of emissions of certain pollutants into the air from large combustion plants and directive for integrated pollution prevention and control.

The Romanian Government's plan to implement Directive 1999/31/EC on the landfill of waste (transposed by HG 349/2005) and Directive 2001/80/EC on the limitation of emissions of certain pollutants into the air, has provided a transition period for comply between 2008 and 2013, which includes all Plants Plants which are using coal (Council Directive 1999/31/CE of 26 April 1999; Directive 2001/80/EC).

As a result of environmental agreements achieved and approvals of the water management, some ash and slag deposits may operate using classical solution (dilution 1/8 to 1/10, slag and ash / water) until 31.12.2015. After this date these deposits will have to be closed and Power Plants (electrical and thermal) will have to operate on gas or to adopt another solution using dense slurry technology (slag and ash / water = 1/1).

The electrical energy in Romania is created by Power Plants (they use different resources, such as, coal, marsh gas, oil fuel etc.), hydroelectrical Power Plants, Nuclear Plant and

Plants that used renewable energies (wind, sun etc).

Currently, the national power system installed capacity is about 18.651 MW, of which:

- 12.664 MW - 67,9% in Power Plants
- 5.278 MW - 28,3% hydroelectrical Power Plants
- 709 MW - 3,8% in Nuclear Plant from Cernavoda.

From 12,664 MW of power in power plants are installed:

- 6.546 MW - power plants using coal
- 6.118 MW - power plants using oil fuel.

According to estimates, at least until 2020, coal will remain the main energy resource of the country, and consumption will be about 30 million tonnes of energy coal annually. Coal burned in power plants comes from domestic production and has the following structure: 90% lignite (poor quality coal) and 10% pit coal.

Because coal used in power plants is of lower quality (90% poor quality coal), the amount of slag and ash resulting from burning is about 28-35 % of the coal burned.

Since it is estimated a consumption of approximately 30 million tons / year, the quantity of slag and ash resulted is about 10 million tons / year. About 95% of the slag and ash is kept in industrial waste storages and the remaining 5% is used in different parts of the economy. The utilization of slag and ash in the economy is reduced due to poor economic concerns and mediocre quality of slag and ash resulted from power plants.

In Romania there are currently 27 ash and slag deposits at 23 power plants in operation. These deposits heights up to 65 m, occupies the land up to 160 ha and contain up to 35 million cubic meters of slag and ash.

Of the 27 available locations to 14 of them were produced different faults and incidents, which consisted of:

- hidroamestec spill over the dam's crest;
- malfunction of drainage system;
- malfunction in the collection and recycling of water.

Because of these accidents and incidents occurred disposals of slopes, dam breaks with gaps of up to 20 m tall, with discharge of tens of thousands of tons of ash and slag, increasing the groundwater in these areas, affecting human settlements and crops, etc..

The transportation between power plants and waste industrial storage is made through hydraulic pumping. According to current technology slag and ash is mixed with water in a ratio of 1/8 to 1/10 (slag + ash / water).

In order to create the storage for slag and ash, the base of the dams must be made first out of local materials. When the storage become almost full the extra elevation dams are created from slag and ash already deposited. Those dams are made with excavators, bulldozers and compactors (Figure 1).

Figure 1. Extending the slag and ash deposit

MATERIALS AND METHODS

The Power Plant from Drobeta-Turnu Severin was used for first time in 1985. It is now equipped with:

- 6 steam boilers of 420 t/h
- 4 turbo aggregates of 50 MW
- 1 turbogenerator of 25 MW
- 1 turbogenerator of 22 MW, powered by coal.

The Power Plant from Drobeta-Turnu Severin is located aproximatly 6 km from Drobeta-Turnu Severin, and the ash and slag deposit is located to about 1.50 km from the power plant, on Trestelnic valley around the Halânga village.

In order to reach the destination from Drobeta-Turnu Severin you must follow the DN 67 which connect Drobeta-Turnu Severin and Târgu-Jiu, and from the power plant to the slag and ash deposit you have to follow a road used in exploitation of the deposit (Figure 2).

The location of the slag and ash deposit is a valley with two compartments that was created through the barring of the Trestelnic creek. The Trestelnic creek is located at aproximatly 5 km upstream from the interconnection with the Danube River. The base of dam was created from local materials, it is 5,5 m tall, the slopes upstream and downstream are 1:3. Through the achievement of the base dam, Trestelnic creek is blocked at aproximatly 2,5 km downstream from the springs that are a 2 km away.

Once filled with slag and ash the deposit was raised with 7 more dams, made with material from the deposit in the "upstream" system. These dams have a height of 5,50 m, upstream and downstream embankment slopes are 1:3.

The Trestelnic creek is 5 km long from the springs to connecting of the Topolniţa River, and the area of hydrographic basin is 4,38 km^2.

River flow is generally reduced, with large fluctuations during the year depending on the amount of rainfall and has a rapid concentration of runoff due to high slope of the river sides.

The valley represent asymmetrical slopes, the the right slope being more steep. Highs increased from 110,0 to 115,0 m in the valley to 250,0 – 300,0 m towards the montains slope.

In the area provided for the dams, the valley is narrow and steep, offering morphological conditions that are favored for damming.

Downstream Tresteln creek crosses the superior terrace of Topolniţa River and creates the south limit of the power plant, the section where the valley was regulated.

In the area provided for the storage, the land contain pastures whith rare clusters of forest.

In this region, along the water, canvas groundwater was discovered, quartered in layers of quaternary gravel and boulders which is powered by the waters infiltrated in the mountains slopes. In the power plants vicinity, on the Danube terrace the underground water that was discovered was in its natural conditions at aproximatly 6 – 12 m. The base rock from around the slag and ash storage has a rich content of clay and the marble has been water-proofed.

In the mountains slopes were not discovered aquiferous layers. In these conditions the contribution of groundwater is insignificant, so store operation is not affected.

Industrial water supply is made for both the Chemical Drobeta-Turnu Severin Plant and for Drobeta-Turnu Severin Power Plant.

The water is carried from the Danube River, upstream from Drobeta-Turnu Severin, in Schela Cladovei village, through the pumping station (caisson type). The water flow capture from the Danube is around 4.812 m^3/h, which is transported through a pipe with 1.000 mm diameter, on a 10 km distance to the Industrial Water Treatment Plant, near Halânga. A part of this flow is sent towards the Industrial Water Treatment Plant on Halânga (Q= 3.812 m^3/h), and the remaining (Q= 1.000 m^3/h) towards the mixing tank of slag and ash from Drobeta-Turnu Severin Power Plant. The water flow that passes through the Industrial Water Treatment Plantfrom Halânga is dispersed towards Chimical Treatment Station (Q= 2.888 m^3/h) where the softening and demineralization process occurs and a 924 m^3/h flow towards different departments used inside of the Power Plant (cooling towers, water storage tanks for fire departments, etc.). (Figure 3).

Figure 2. General layout.

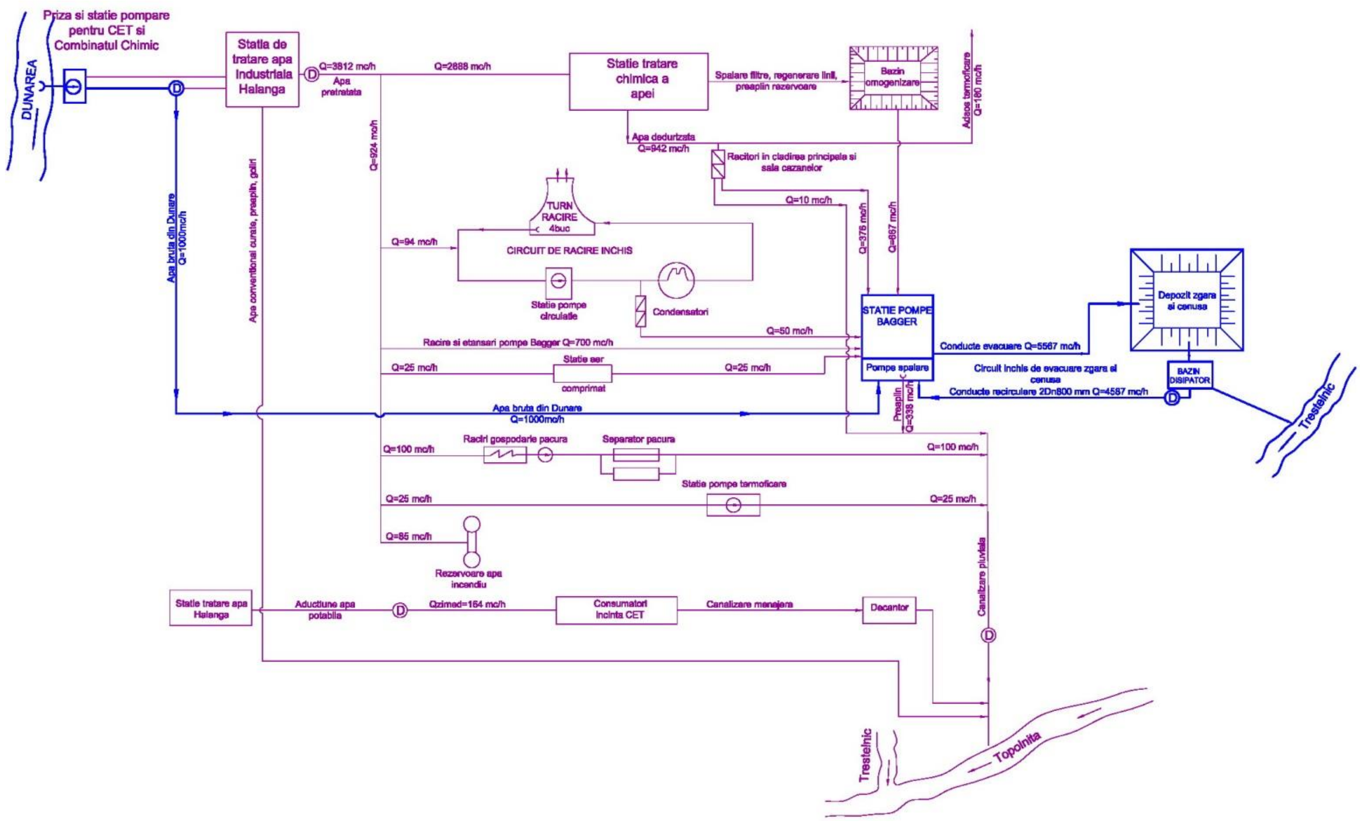

Figure 3. Hydraulic circuit

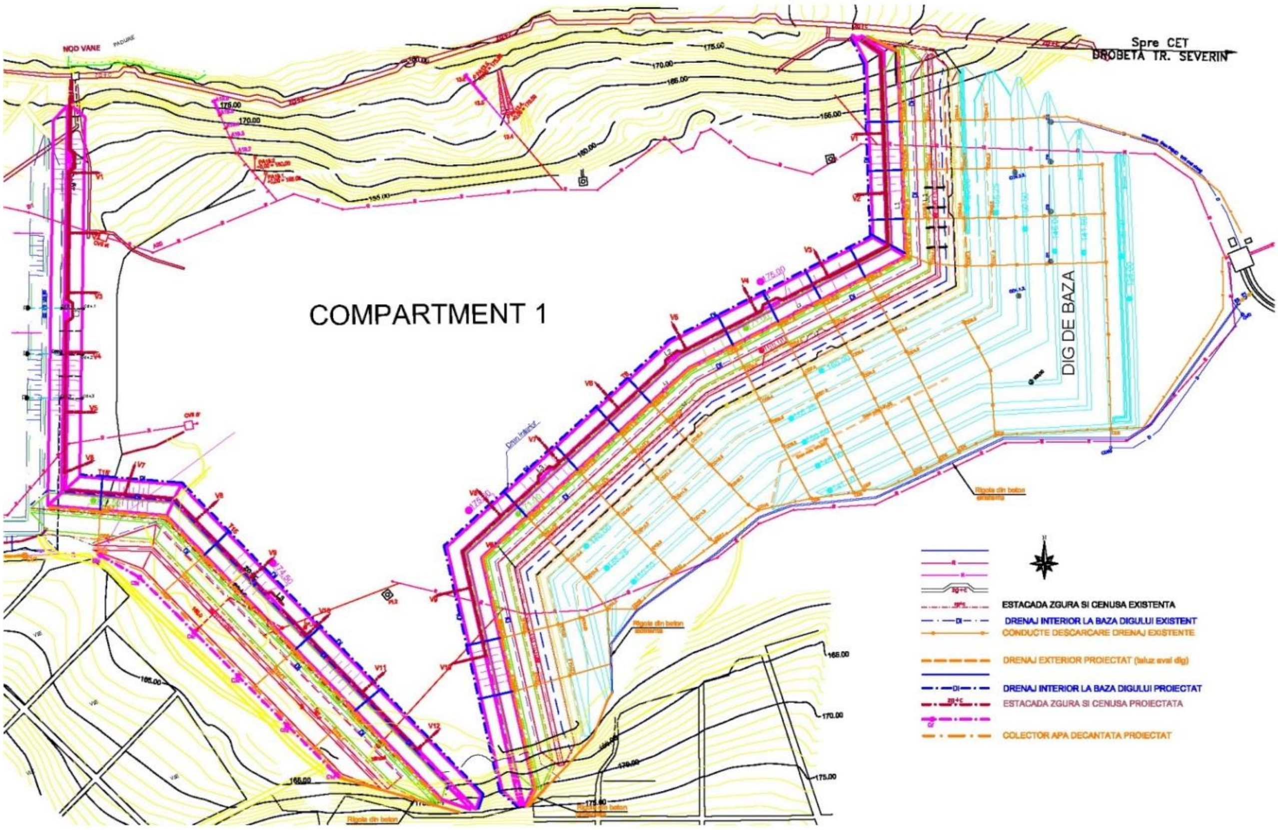

Figure 4. Overview of the deposit

The left over slag from the 6 steam boilers is crushed and then mixed with the ash from electro filters and with water in a mixing tank. The mixed percentage is 1:10 (slag and ash/water). Through pumping the mix is carried through a pipe that has a 400 mm diameter to the slag and ash deposit.

From the transfer pipes the mix reaches the distribution tubes (D= 400 mm) inside of the deposit. There is one distribution pipe in each compartment and extends over three sides of the compartment (Figure 4).

From the distribution pipes, the mix reaches the deposit using discharge pipes (D= 250 mm) provided with valves (Figure 5).

A couple of those pipes are always open in a aleatory way in order to achieve uniform filling of the compartments.

A part of the decanted water from the deposit is evacuated in the exterior through wells and spillway collections and the other part through the interior and exterior drainage systems.

The water from the deposit, that originated from slag and ash mixture, the water drained from the Trestelnic valley to the storage area and the one from precipitations is ejected onto the exterior of the storage through a collection of spillways and wells (3 pieces in each compartment) and a drainage system. Through the evacuation system of the water from the storage, the discharge over the top part of the dams is avoided and also their stability is ensured.

Figure 5. Discharge pipe

A part of the water from the deposit is collected through wells and ejected onto the exterior through the pipes that pass under the dam. The spillway collection are made out of a prefabricated reinforced concrete (D= 1.000 mm, h=0,15 m). These rings allow to rise the wells with increasing amount of slag and ash deposited and also raising the water level in the deposit. The exhaust pipes of the water collected in the collection wells are made of steel (D= 700 mm).

The interior drainage of the deposit is made at the upstream foot of the embankment on all its length. The water is collected through PVC pipes with 110 mm diameter, provided with gaps of 0,5x10,0 cm. These drains discharge from place to place in the concrete manholes (D= 1.000 mm), and from here, through PVC pipes with 150 mm diameter, without gaps, these pipes cross through the dam and the water is ejected in exterior drainage. The distance between the evacuation tubes is approximately 35 m. The exterior drainage is comprised out of concrete manholes (D= 1.000 mm), and corrugated pipes with 110 mm diameter located downstream at the bottom of the dams. The drainage pipes are placed in the trenches with 0,85 m depth at the interior drainage and 0,70 m at the exterior drainage. The drain filter is made out of geosynthetic filter material, the drain material (stone 30-70 mm) and ballast or gravel protection of 0,2-70 mm. The execution of the interior drain and the evacuation pipes is made before the start of the over height dam, and the exterior drainage after the execution of the new dam (Figure 6).

The water collected in the manholes executed on the exterior part of each dam, water collected by the drainage system inside and outside the dams, is discharged through pipes having 150 mm diameter to the perimetral channel located at the base of the dam.

The water evacuated through the interior and exterior drainage system of these dams with the water from the collection wells is directed towards the slag and ash chamber. In this way, it is recycled in the hydro mechanincal transport system.

(Project for extending the slag and ash deposit from Drobeta-Turnu Severin).

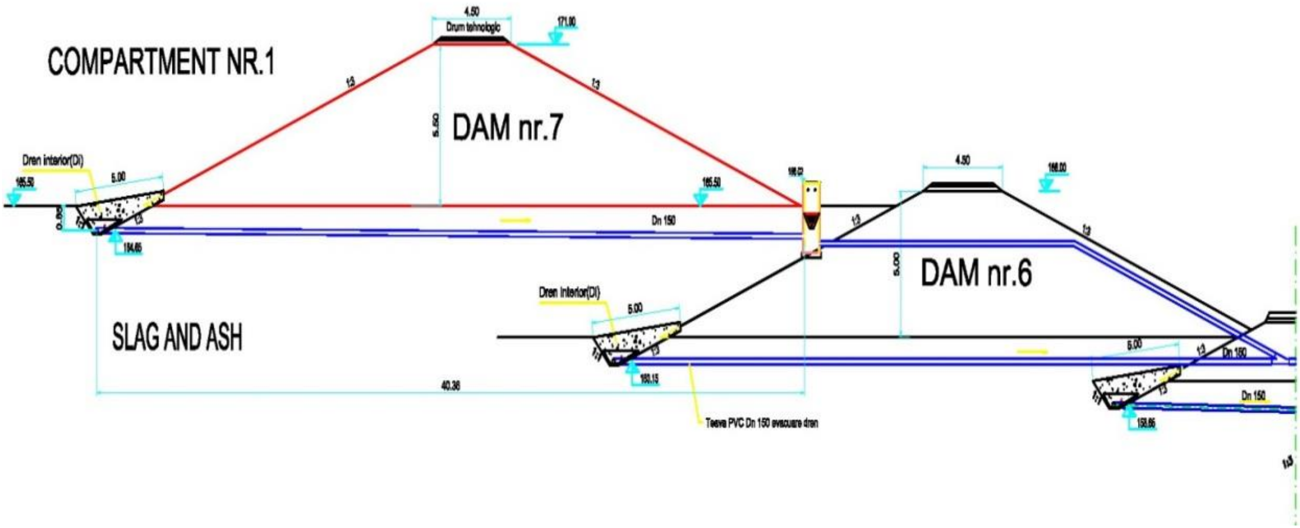

Figure 6. Dam number 6 and number 7. Cross section.

RESULTS AND DISCUSSIONS

The waste of slag and ash from the deposit have the following composition: ash (70% - 90%), slag and unrecoverable waste (10% - 30%). Physical, chemical and mineralogical properties of the ash varies based on the type of coals burned, technology and burning installations.

The ash from the Drobeta-Turnu Severin deposit has a sandy look, dark gray color (almost black) and contains between 3% and 5% coal. Mineralogical analysis of the ash reveals uncemented structures, weakly compacted with iron, quartz, feldspars, oxides, and mineral granules. Two types of slag and ash were determined:

- A type (rough), with 75% -85 % sand, 10% clay and 5% dust;
- B type (medium and fine), with 50% sand, 6% clay and 44% dust.

The physic-mechanical characteristics of the ash from the deposit, which is important for deposit's stability are: the friction interior angle

$\alpha = 30^0$, cohesion C = 0-40 Kpa, densities γ = 1,10-1,25 to/m^3, permeability k = 10^{-3}-10^{-5} cm/s. The chemical analysis of the ash proved the identification of free oxides with the silicon, iron, aluminum and calcium accent (Table 1). Those have a positive influence over the cohesion of the particles. Others like magnesium, potassium and sodium oxides have negative effects because they favor some oxidation or expansion phenomena. In time the filterability coefficient will become smaller. The chemical composition of the ash indicates a small affinity for water, reducing the retention of the water in deposit. (Geological, geotechnical and hydrogeological study).

Table 1. The chemical composition of ash from Drobeta-Turnu Severin Power Plant.

Concentration (%)	SiO_2	FeO_3	Al_2O_3	CaO	MgO	K_2O	Na_2O
Minimum	50,12	9,85	25,23	4,82	1,05	0,95	1,21
Average	52,65	10,65	26,37	5,01	1,31	1,01	1,41
Maximum	58,07	11,72	28,23	5,17	1,84	1,16	1,57

The slag and ash that results from the burning of coal is transported in mixture with the water from Danube River, in deposit where the decantation process of the solid particles occurs. The mixed result has alkaline character (*p*H = 8,5-8,8) and contains: suspensions (15-160 mg/l), fixed residue (1.200-1.300 mg/l), chlorides (50-75 mg/l), sulfates (700-900 mg/l), Na^+ (30 mg/l), Mg^{2+} (50 mg/l), Ca^{2+} (250 mg/l). The mineralization degree of the mixture is due to the soluble character of the salts (chlorides, sulfates) from ash.

The results of the chymical analysis of decanted water, the water collected through the drainage network, the mixture and the water from Trestelnic creek are represented in the Table 2.

Table 2. Water features: decanted, from drainage, mixt water, and from Trestelnic creek.

Indicators	UM	Water				NTPA001/2004
		decanted	drainage	mixt	Trestelnic	
*p*H		8,2	8,0	7,6	7,85	6,5-8,5
Suspensions	mg/l	-	-	-	197	35,0-60,0
Fixed rezidue	mg/l	2.800	1.283	860	529	2.000
Chlorides	mg/l	190	89	36	160	500
Sulfates	mg/l	1.452	574	462	122	600
Nitrite	mg/l	0,5	0,5	0,2	0,40	1,0

The waters from the slag and ash storage from Drobeta - Turnu Severin Power Plant have alkcaline characteristics, a high degree of mineralization and high concentration of sulfates and chloride. Because of those characteristics the accidental evacuation of the collected water into the Trestelnic creek will produce pollution.

The evaluation of the undergrown water quality can be realized through a sample out of 5 drillings executed downstream from the deposit. Groundwater level in deposit area is between 6 and 12 m beneath the ground level. In this paper we present the results of the undergrown water quality between 2009-2012.

The groundwater quality parameters (registered after the quarterly physico-chemical analysis done between 2009-2012), were compared with the limited values admited in Law 458/2002 – The drinking water law (Table 3).

Table 3. The quality of groundwater near Drobeta-Turnu Severin slag and ash deposit.

Indicators	UM	Value			Law 458/2002
		minimum	average	maximum	
*p*H		6,5	7,2	9	6,5-9,5
SO_4^{2+}	mg/l	25,0	188	240	250
Cl^-	mg/l	3,2	43,1	316	250
Mg^{2+}	mg/l	0,2	24,0	152	
CCO-Cr	mg/l	9,1	41,9	72	
CCO-Mn	mg/l	6,0	14,8	117	
Electrical conductivity	µs/cm	170	1100	2147	2500 µs /cm
Fixed rezidue	mg/l	160	909	3690	

CONCLUSIONS

The burning of poor quality coals in the electrothermal plants from Romania has resulted in a large quantity of slag and ash. The

transport of these residues (mixed in percentage of 1/10 ash+slag/water) from the plants to the storage units of slag and ash needs a large quantity of water. The collected and ejected water from the storage is recycled.

The reduction of the quantity of water used for the transport can be achieved by using the dense slurry technology (mixed in a percentage of 1/1 slag+ash/water). As a result of environmental agreements achieved and approvals of the water management, some ash and slag deposits may operate using classical solution (dilution 1/8 to 1/10, slag and ash / water) until 31.12.2015.

The location of the slag and ash deposit from Drobeta-Turnu Severin is in an area that has a hard pemeable ground. With a sufficient working dam and a good drainage system, small anounts of water infiltrates from the deposit in the groundwater. Based on this fact, the rise of the groundwater is not recorded.

The infiltration of polluting substances in the water from the deposit is reduced and does not affect in any important way the quality of the groundwater from this area.

It is best to monitor the evolution of the level and quality of the groundwater fom this area.

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REFERENCES

Council Directive 1999/31/CE of 26 April 1999 on the landfill of waste.

Directive 2001/80/EC on the limitation of emissions of certain pollutants into the air from large combustion plants.

Geological, geotechnical and hydrogeological study made for the slag and ash deposit placed on Trestelnic valley corresponding to DROBETA-TURNU SEVERIN Power Plant.

Law 458/2002 – The drinking water law, completed with law 311/2004.

NTPA001/2002 - setting limits on pollutants charging industrial and municipal wastewater witch are discharging into natural receivers.

Project for extending the slag and ash deposit from DROBETA-TURNU SEVERIN. Stage II. Compartment number I. Dam no.7 to 171,00 m.