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ABSTRACT

Alcanena is a municipality located in the center of Portugal where about 85% of the Portuguese tanning industries are located, representing 65% of the national production. During decades the industrial waste was disposed directly in the soil and the waste waters discharged into the river without any treatment. Following the recent Portuguese environmental policy, the national authorities decided to rehabilitate this area. First, by the construction of a waste water treatment plant (WWTP) and a impermeabilized lagoon for WWTP mud deposition, then by the construction of a landfill for deposition of the tanning scraps and, finally, when the maximum capacity of the lagoon was reached, by the construction of a landfill for deposition of the pre-treated WWTP muds. In this paper special importance will be given to this landfill, to the mud pre-treatment procedures and to the air and water monitoring systems.

KEYWORDS

Landfill, industrial waste, muds, pre-treatment, impermeabilization system, monitoring systems.

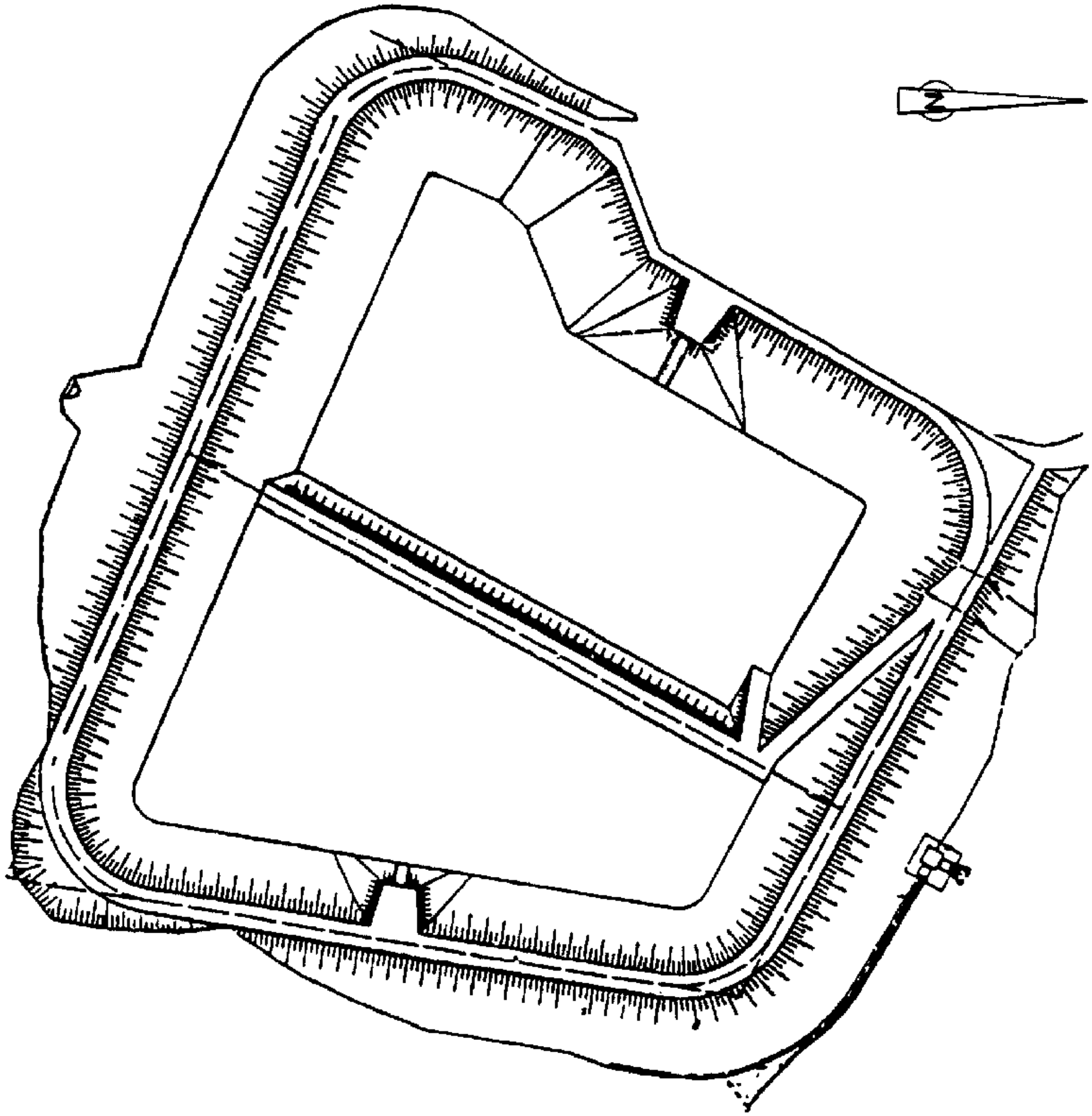

Fig. 1 Schematic plant of the Alcanena industrial waste landfill

INTRODUCTION

Alcanena is a municipality located in the center of Portugal where about 85% of the Portuguese tanning industries are located, representing 65% of the national production. During decades the industrial waste was disposed directly in the soil and the waste waters discharged into the river without any treatment. Due to the high degree of toxicity of the tanning industry waste, the Portuguese authorities decided, in the 70's, to rehabilitate the Alcanena area. The first step was the construction of a waste water treatment plant (WWTP) and a impermeabilized lagoon for WWTP mud deposition, followed by the construction of a landfill for deposition of the tanning scraps. However, as the WWTP muds presented a high percentage of grease and were not pre-treated they released toxic products and pestilent odours during deposition, the maximum capacity of the lagoon being, soon, reached. Then, it was decided to close the lagoon and construct a landfill for deposition of the pre-treated WWTP muds. Meanwhile, the muds were being deposited in a temporary non-impermeabilized cell and its stabilization prior to landfill deposition started to be done.

WASTE LANDFILL FOR WWTP MUD DEPOSITION

Description and Phases of Construction

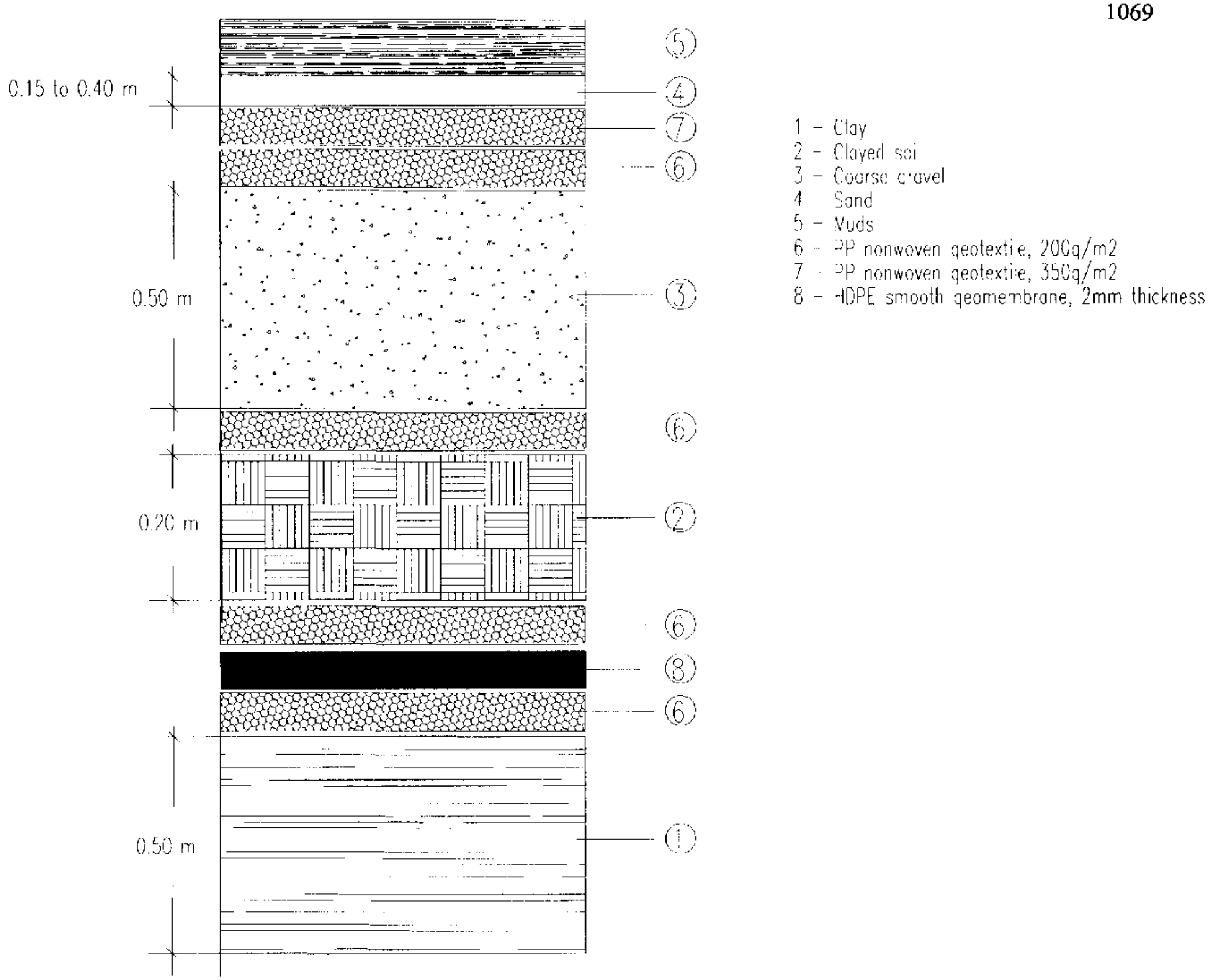

Fig 2 Base impermeabilization and drainage system.

The Alcanena industrial waste landfill, schematically represented in plant in Fig. 1, is composed of two impermeabilized cells with 2H:1V lateral slopes.

The deposition area is about 38500m^2. As the top level of the lateral slopes can not be exceeded, the total height available for waste deposition plus closure system is 13m. In those circumstances the total capacity of the landfill for waste deposition is about 400000m^3. The landfill design life is about 15 years. The permeability of the landfill surrounding soil is about 10^{-9}m/s.

The construction of the landfill was carried out in the following sequence:

1) construction of the East cell and of the central separation septum from West cell;
2) muds temporarily disposed transfer to the East cell (about 30000m^3), after dehidration and chemical stabilization, followed by soil decontamination of the previous area of deposition;
3) construction of the West cell.

Impermeabilization and Drainage Systems

The base and lateral impermeabilization and leachate drainage systems were executed in accordance with the more recent European legislation for toxic waste landfills.

In Fig.s 2 and 3 can be seen the impermeabilization and leachate drainage systems executed, respectively, in the base and in the lateral slopes of the Alcanena industrial waste landfill.

The base impermeabilization and drainage system has the following constitution from the foundation upwards: - 0.50m thickness clay layer with a permeability of 10^{-9}m/s; - PP nonwoven geotextile, 200g/m^2; - HDPE smooth geomembrane, 2mm thickness; - PP nonwoven geotextile, 200g/m^2; - clayed soil, as protection layer, with 0.20m thickness; - PP nonwoven geotextile, 200g/m^2; - coarse gravel, as drainage layer, with 0.50m thickness;

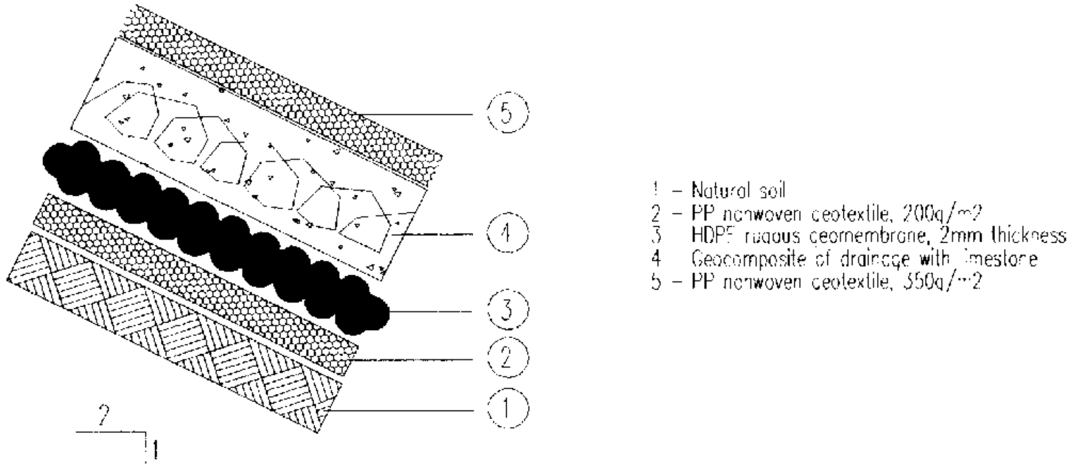

Fig. 3 Lateral impermeabilization and drainage system.

- PP nonwoven geotextile, 200g/m^2; - PP nonwoven geotextile, 350g/m^2; - sand layer with 0.15 to 0.40m variable thickness.

The lateral impermeabilization and drainage system has the following constitution from the natural soil upwards: - PP nonwoven geotextile, 200g/m^2; - HDPE corrugated geomembrane, 2mm thickness; - geocomposite of drainage with a PP core and limestone gravel with 0.002 to 0.008m variable dimension; - PP nonwoven geotextile, 350g/m^2.

Landfill Exploration Methodology

In the Alcanena landfill the mud, after dehidration and chemical stabilization is disposed in layers of 0.30m thickness. The mud degree of dehidration to be achieved is about 35% of dry matter. The mud treatment is of utmost importance as it releases toxic products, such as: chromium trioxide, methylmercaptan, carbon disulphide, hydrogen sulphide, toluene and ammonia. The mud treatment product is a mixture of pulverized residual ashes and other hydraulic agglutination agents that react with the water present in the muds. During this dehidration process the mud pores are closed, the harmful substances isolated and the muds stabilized. The mixture pH becomes alkaline (>11), the pathogenic agents being eliminated. The ammoniacal odours released by treated muds are almost imperceptible, the final product being safe and easy to handle and transport.

Table 1 - Mud stabilization control parameters. Limit values.

Parameter	Limit Value
Shear Strength	>25kPa
Axial Strain	<20%
pH	5.5 - 13.0
Compression Strength	>50kPa

The limit admissible values for the control parameters of mud stabilization are presented in Table 1. For safety reasons the treated mud must have enough load capacity under the site machinery and the required dehidration, not to be contaminant of the machinery and of the access tracks, do not produce health problems on the workers and do not release unconfortable odours.

After stabilization the mud is spread, on the landfill, over an area of about 2000m^2 in 0.30m thickness layers. Mud stability control tests are carried out after 1, 3 and 7 days of deposition for each 600m^3 (2000x0.30m^3) of mud, being then compacted. The tests carried out during mud deposition concern basically the determination of shear strength, pH, dry matter percentage and compaction parameters. The muds are moved by large width tracks vehicles with low contact pressure (<120 g/cm^2).

Control and Monitoring Systems

The control and monitoring systems of the Alcanena industrial waste landfill concern air and subterranean water quality.

Table 2 - Wells. Depth and flow.

Well Designation	Depth (m)	Flow (l/s)
1	8	-
2	16	0.5
3	17	2.0
4	17	1.5
5	87	1.0
6	184	4.0
7	301	25.0

Table 3 - Water quality control parameters. Maximum and minimum values.

Parameter	Well													
	1		2		3		4		5		6		7	
	Máx.	Min.	Máx.	Min.	Máx.	Min.	Máx.	Min.	Máx.	Min.	Máx.	Min.	Máx.	Min.
Nitrates (mg/l)	61.70	50.70	7.86	3.98	51.40	37.10	1.57	0.75	61.60	11.60	1.33	1.66	37.70	2.73
Sulphates (mg/l)	269.0	176.0	24.8	<5.0	366.0	269.0	13.4	<5.0	329.0	117.0	21.4	<5.0	254.0	39.7
Bicarbonates (mg/l)	401	389	340	328	438	389	276	249	489	407	231	237	626	261
Nitrites (mg/l)	0.38	0.02	<0.02	<0.02	0.25	0.10	<0.02	<0.02	0.16	0.09	<0.02	<0.02	0.45	0.02
Chlorides (mg/l)	310.0	243.0	38.8	17.6	832.0	388.0	65.2	58.2	670.0	441.0	61.6	52.9	635.0	201.0
Calcium (mg/l)	180.0	166.0	143.0	125.0	475.0	452.0	87.4	75.2	400.0	279.0	79.6	74.9	394.0	192.0
Potassium (mg/l)	5.93	3.35	3.25	2.48	2.87	1.40	4.44	3.44	1.65	0.65	5.64	4.36	8.37	1.78
Magnesium (mg/l)	7.42	5.95	3.05	2.37	13.40	11.20	13.00	10.10	10.20	6.69	8.99	7.86	12.2	9.93
Sodium (mg/l)	246.0	194.0	11.6	10.7	344.0	279.0	22.2	19.4	386.0	196.0	28.3	22.6	314.0	113.0
pH	7.17	7.05	7.28	7.15	7.12	6.96	7.48	7.37	7.01	6.84	7.47	7.43	7.29	6.68
Conductivity (μS/cm)	1801	1528	623	436	3250	2408	547	537	2989	2021	514	498	2827	1074
Hardness (mg/l $CaCO_3$)	474	440	368	321	1230	1178	272	229	1037	725	231	224	1033	520
Cromium (μg/l)	5.30	<1.80	3.80	<1.80	6.78	5.53	1.94	<1.80	9.11	4.47	6.00	2.62	7.31	1.90
Iron (mg/l)	0.08	<0.03	0.05	<0.03	0.08	<0.03	0.10	0.03	0.07	<0.03	0.05	<0.03	0.67	0.13
Nickel (μg/l)	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	6.2	<5.0	<5.0	<5.0	31.6	5.0
Manganese (mg/l)	0.59	0.20	<0.03	<0.03	0.48	<0.03	0.10	<0.03	0.15	0.06	<0.03	<0.03	0.42	0.03
Zinc (mg/l)	0.11	<0.05	<0.05	<0.05	0.06	<0.05	0.21	0.14	<0.05	<0.05	0.24	0.07	0.36	<0.05
Oils / Greases (mg/l)	0.23	0.08	0.24	0.11	0.14	0.04	0.96	0.14	0.12	0.12	0.10	0.10	0.12	0.08

The water quality control program started by characterizing the water quality to be used as reference in future campaigns. To achieve this objective seven wells were drilled. The depth of the wells and the flow measured are shown in Table 2. Piezometers were then placed downstream of the lagoon, of the provisional non-impermeabilized cell, of the landfill for deposition of the tanning scraps and of the industrial waste landfill. During the landfill construction and during its first year of exploration the sampling periodicity is monthly. After that, and depending on the analyses, the sampling periodicity can be widened to 3 months. After landfill closure sampling will be done every six months. The water quality control concerns physical and chemical parameters, such as: nitrates, sulphates, bicarbonates, nitrites, chlorides, calcium, potassium, magnesium, sodium, pH, conductivity, total hardness and, also, the concentration of heavy metals (such as: cromium, iron, nickel, manganese and zinc), not forgetting the oils and greases. Table 3 shows the maximum and minimum values measured for the water quality control parameters, in each well, during the landfill construction.

The program of air quality control comprised two phases: one during mud transfer and another during landfill exploration and after its closure.

Table 4 - Maximum concentration of pollutants in the first phase of the air quality control program.

Polluent	Equipment	Measurement Method	Periodicity	Maximum Concentration	Allowed Limit Value
Sulphur Dioxide	EMS Sensor ELE International	Electrochemical	24 hours	1.392p.p.m	2p.p.m
Hydrogen Sulphide	EMS Sensor ELE International	Electrochemical	24 hours	0.831p.p.m	10p.p.m
Carbon Disulphide	Dragger Tubes	Chemical	Variable	1p.p.m	10p.p.m
Ammonia	Dragger Tubes	Chemical	Variable	68p.p.m	25p.p.m
Chromium Trioxide	Dragger Tubes	Chemical	Variable	0p.p.m	0.5mg/m^3
Methane	Gas Analyser (GA 94 A)	Spectrophotometric (IR)	Variable	0p.p.m	-
Methylmercaptan	Portable Gas Chromatograph Unit	Chromatographic	Variable	0p.p.m	0.5p.p.m
Toluene	Dragger Tubes	Chemical	Variable	0p.p.m	100p.p.m

The measured pollutants are chromium trioxide, methylmercaptan, carbon disulphide, hydrogen sulphide, toluene, ammonia, carbon dioxide, sulphur dioxide and methane. The meteorological factors considered are the wind direction and the wind speed, the air and soil temperatures, the air relative humidity, the solar radiation and the rainfall.

The monitorization equipment is composed of: -a fixed station that regists data continuously and is equipped with meteorological instruments and electrochemical sensors for hydrogen sulphide and sulphur dioxide; -a methane and carbon dioxide analyser; -a portable gas chromatograph unit to measure compounds reduced from sulphur and toluene; -gaseous detectors tubes to measure ammonia, chromium trioxide and some compounds reduced from sulphur; -as a safety measure, the fixed station has an alarm system that is triggered when the hydrogen sulphide concentration gets near to the allowed limits. Initially the fixed station was positioned near the mud remotion area to characterize the air quality available for the workers. Later, it was transferred to the North of the industrial landfill, so as not to obstruct machinery movements. The chromatograph is used in the area of landfill influence. The location of the chosen measurements sites, and the periodicity of measures depends on the meteorological conditions and on the previous results. The registered values are compared with the limits defined in the Portuguese standard for hygiene and safety at work (NP 1796, of 1988).

Table 4 shows, for the first phase of the air quality control program, the maximum concentration measured for the different pollutants in the landfill area, the limit values defined in the Portuguese standard NP 1796, of 1988, and the measurement method. As it can be seen from Table 2 the concentration in the air, during the first phase of the program, of the different pollutants is, in almost all cases, below the standard limits. In fact, only the ammonia concentration exceeds the limit allowed.

In what concerns the second phase of the air quality control program it must be said that probably some adjustements will be required in the selection of pollutants to control, in the periodicity of the measurements and in the sampling areas. After the landfill closure the methane will be measured with the objective of controlling possible releases.

CONCLUSIONS

Although, at the moment this paper is being written, the landfill is at the end of the second phase of its construction (muds temporarily disposed transfer to the East cell, after dehidration and chemical stabilization) it can be said that the quality of air and water is within the allowed limits, which gives optimistic perspectives in relation to the efficiency of the adopted solution of deposition of the pre-treated mud in landfill. This efficiency will be of the utmost importance for the environmental rehabilitation of the Alcanena and surrounding areas.

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