proceedings

MDPI

Proceedings

Earth Dam Monitoring in the Soil Take Care Project †

Martina Inmaculada Álvarez Fernández [1,*], Celestino González Nicieza [1], Román Fernández Rodríguez [2] and Juan Ramón García Menéndez [2]

[1] Exploitation and Prospecting mines, University of Oviedo, Oviedo 33004, Spain; cgnicieza@git.uniovi.es
[2] Research Group of Ground Engineering, Mining Engineering College, Oviedo 33004, Spain; roman@git.uniovi.es (R.F.R.); juan@git.uniovi.es (R.G.M.)
* Correspondence: inma_alv@git.uniovi.es; Tel.: +34-985-10-42-66
† Presented at the 2nd International Research Conference on Sustainable Energy, Engineering, Materials and Environment (IRCSEEME), Mieres, Spain, 25–27 July 2018.

Published: 21 November 2018

Abstract: The Cartagena-La Unión mountain range was the focus of an intense mining activity between early XIX and late XX centuries. Most of Spanish national production of lead and zinc was extracted from its mines. During the ore concentration process, contaminated wastes containing heavy metal minerals, cyanides and sulfates were produced and deposited in earth dams. The Spanish National Institute of Geology and Mining had catalogued 75 earth dams in the councils of Cartagena and La Unión. These deposits pose a potential risk for the environment and nearby populations. Without suitable and precautionary measures, contaminated particles can be transported far away due to the wind action and runoff water, and may be incorporated to the food chain. This risk is increase due to the fact that it is a seismically active area, and breakage of these dams can lead to the dumping of thousands of tons of contaminated wastes. The SOIL TAKE CARE Project is an international project co financed by the European Regional Development Fund (ERDF) through the Interreg Sudoe Cooperation Programme. It aims to improve the management and rehabilitation of contaminated soils in South-Western Europe that includes Spain, Portugal and south of France. The University of Oviedo takes part of that Project by the instrumentation and monitoring of two of those earth dams. Among the work realized so far highlights the perforation of two boreholes and the installation of several sensors. It aims a double objective: to analyze the erosion and infiltration capacity of rainfall into the dams and to detect possible symptoms of slope instability. Although the investigation is still in course, preliminary results shows fast rainfall infiltration into the superficial soil layers, being discharge curves much more extended. This water retention capacity, coupled with the existence of impermeable layers into the dams, could lead to a complete saturation of superficial soil layers and trigger slope instability processes.

Keywords: Interreg Sudoe; SOIL TAKE CARE; earth dam; monitoring; contaminated wastes

1. Introduction

Soil contamination by heavy metals is a worldwide problem for human health and safe food production. Except for uncommon geogenic origins, heavy metal contaminants are inadvertently introduced to soils through anthropogenic activities such as mining and waste disposal [1].

Inappropriate soil disposal of mine spoils and industrial waste frequently causes heavy metal contamination [2].

This is the case of many locations of the South-Western of Europe which are affected by contamination because of metals. This contamination affects soils and its functions, but also, surface and groundwater, the atmosphere and the human being through the breathing or the ingestion [3].

Public authorities in charge of the environmental management, have to deal with two important issues in terms of costing: establishing accurate inventories of contaminated locations and defining the solving process.

The SOIL TAKE CARE Project [4] aims to improve the management and rehabilitation of contaminated soils in South-Western Europe that includes Spain, Portugal and South of France.

The University of Oviedo takes part in this Project by the instrumentation and monitoring of two earth dams of mud in the Cartagena-La Unión mountain range, in the Murcia region (Spain), where the Spanish National Institute of Geology and Mining has catalogued 75 dams of contaminated tailings by heavy metals, the majority of them abandoned [5].

2. Decision of Locations and the Equipment Used

The decision of the areas for instrumentation was made from two points of view: the potential risk in case of instability and the general interest of the emplacement for the development of work that the different partners of the Project have to carry out. Thus, two locations were chosen in the places known as El Avenque Rambla and El Descargador (see Figure 1).

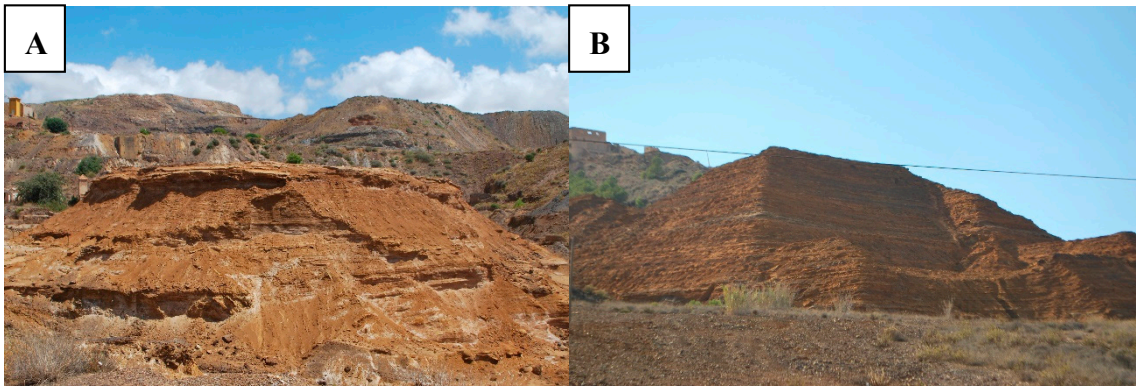

Figure 1. Earth dams in El Avenque (**A**) y El Descargador (**B**).

2.1. El Avenque Rambla

It is about a basin of water reception whose natural exit is an embedded valley with a torrential riverbed which flows into El Gorguel Beach. It is about an area of great interest considering that in the water reception area until 8 earth dams of different sizes are located for the stocking of mud with heavy elements. Therefore, the study in this area allows analysing the loss of material from earth dams due to the fact of instability phenomena and/or erosion and, the transport of contaminating elements from the deposit zone to the sea.

Among all present earth dams in this area, the named one as 0977-4-0037 (according to IGME's nomenclature) was chosen because it shows a displacement scar at the bottom and too vertical slopes, so it is liable to undergo new displacements.

As a result, a biaxial inclinometer was installed to try to detect possible circular displacements in one of its slopes and, two moisture sensors in order to analyse the infiltration capacity of rainfall. Besides, other four moisture sensors were installed in the alluvial plain and in the riverbed of one of the runoff water which flow into the embedded valley that runs into the sea. These devices will be useful for giving support and being complementary with the other tasks carried out by the rest of the partners of the Project.

2.2. El Descargador

In this place a great pyramidal earth dam (977-4-0027) is located, in which, according to IGME's estimation, the gathered volume of tailings and mud is 370,000 m^3. It has been catalogued as B Category by the Spanish National Institute of Geology and Mining. *Mud* deposits that its failure or wrong working may cause important damages on the elements on risk or affect to a specific number of housing, [6].

During the reconnaissance, the presence of wet zones in the limited number of benches was observed. As consequences, six moisture sensors were installed under the surface, in order to check the seasonality of these ponds, and its possible connection with the rainy seasons.

Due to the fact that the area under study is located in a seismically active region, one of the main concern regarding to this type of deposits, is to know which is the current state of the spilled mud at that moment, because, in case the mud had been solidified, the response to a specific seismic movement would be more positive than if it was in a liquid state.

With the aim to analyse the state and the competence of the gathered mud and tailings, two boreholes were drilled, carrying out in-situ penetration tests and collecting unaltered samples.

Afterwards, these boreholes were instrumented by technicians from the Ground Engineering Research Group of the University of Oviedo, using piezometers and six moisture sensors, with the aim to analyse possible rainfall infiltrations inwards earth dam, and, in this case, to estimate the pore pressure.

Also, other zones in this earth dam were instrumented using three wire extensometers_which measure possible opening of cracks and the falling of corbels from the monitoring slopes. In addition to these sensors, a biaxial inclinometer was placed in a nearby point, in order to register possible rotational displacements.

With the aim of relating the measures from these sensors to the surrounding environmental conditions, at the Public Defense Headquarter in La Unión, a weather station was set which includes a weather-vane, an anemometer, a rain gauge and a temperature sensor.

Finally, it was requested the Portman Golf Company's cooperation for placing a seismic station in one of their facilities located a short distance from *El Descargador* spot. In this way, the registered intensity in the area under study of those possible seismic events will be analysed, paying close attention to the effect on the stability of the main surrounding earth dams.

3. Preliminary Results

So far, preliminary results shows fast rainfall infiltration into the superficial soil layers of the ground and a certain water retention capacity, being discharge curves slower than the charge one (see Figure 2).

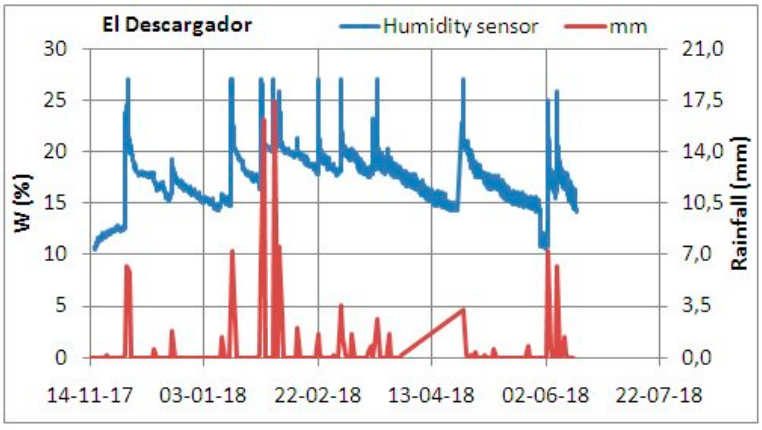

Figure 2. Connection between moisture and precipitations.

Besides, sensors buried 4 m deep show similar behaviour to those placed under surface. However, this infiltration capacity does not show an increase of the pore pressure in the centre of the earth dam because; the piezometers placed over 10 m deep in *El Descargador* spot, are not registering so far noteworthy variations. This is likely due to the combination of low-intensity rainfall and the possible presence of clayey horizons that make difficult the flowing of the water inward of the earth dam.

With respect to this, it must be highlighted that the identification test made on unaltered samples collected inside *El Descargador* spot, show what it is about silt and its content of water is over the liquid limit. Therefore, what it is about non-cohesive material.

As a consequence, if the complete saturation of dams and superficial layers is reached, a fluidification of these and the break of the earth dams may be caused. This is the reason why the surrounding seismic control gains great importance. On this matter, it must be shown that, so far, the seismic station placed nearby *El Descargador* spot has not registered any event at the area under study.

Finally, regarding the control of cracks and possible instability phenomena, it should be emphasize the movement detected by one of the extensometers placed on *El Descargador* spot that, at the beginning of 2018, detected a 6 mm leap (see Figure 3).

Also, it should be underlined the 0.2° movement registered in the same earth dam by the biaxial inclinometer placed a short distance away from extensometer, three months later. In any case there is no direct connection with the rainfall seasons.

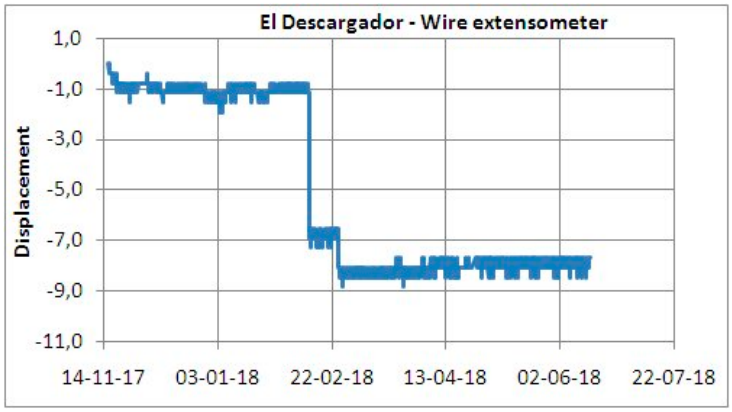

Figure 3. Wire extensometer placed on *El Descargador* spot.

4. Conclusions

Although the research is still in course, preliminary results show a fast rainfall infiltration into the superficial layers, being discharge curves much more extended. This water retention capacity, coupled with the presence of impermeable horizons into the dams, could lead to a complete saturation of superficial soil layers and trigger slope instability processes.

Acknowledgments: The SOIL TAKE CARE Project is co financed by the European Regional Development Fund (ERDF) through the Interreg Sudoe Cooperation Programme.

References

1. Liu, L.; .Li, W.; Song, W.; Guo, W. G. Remediation techniques for heavy metal-contaminated soils: Principles and applicability. *Sci. Total Environ.* **2018**, *633*, 206–219.
2. He, Z.L.; Yang, X.E.; Stoffella, P.J. Trace elements in agroecosystems and impacts on the environment. *J. Trace Elem. Med. Biol.* **2005**, *19*, 125–140.
3. Jaishankar, M.; Tseten, T.; Anbalagan, N.; Mathew, B.B.; Beeregowda, K.N. Toxicity, mechanism and health effects of some heavy metals. *Interdiscip. Toxicol.* **2014**, *7*, 60–72.
4. Available online: http://soiltakecare.eu/ (accessed on 1 November 2018).
5. Available online: http://info.igme.es/balsas/ (accessed on 1 November 2018).
6. Ministerio de Industria y Energía de España. ITC 08.02.01. «BOE» núm. 111, de 9 de mayo de 2000, páginas 17235 a 17244. Available online: https://www.boe.es/buscar/doc.php?id=BOE-A-2000-8528 (accessed on 1 November 2018).