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Study of Wind Erosion in Tailings Deposits

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Abstract

The methodology followed in this research has made it possible to make contributions in the administrative, but mainly technical, field to define the negative impacts generated by wind erosion in a tailings deposit, information that can be used to define actions to be followed to minimize its impact. The research was carried out in a tailings dam in the Atacama Region, Chile that is in operation, within the framework of the development of the FONDEF D06I1097 project and the doctoral thesis "Measurement system of the stability of mining tailings deposits against the wind action, for its recovery as a sustainable urban space. The case of the city of Copiapo in Chile", presented in 2016 at the Polytechnic University of Madrid, Spain [1].

Keywords: Tailings Deposit; Wind Erosion

Introduction

Mining has been practiced in Chile for several centuries, which has contributed to the country's progress. However, this activity constitutes a potential risk of affectation for people and the environment. Tailings require special attention to control the negative effects that wind erosion can cause. Wind erosion of the soil is a natural phenomenon; however, human activity has accelerated it, making it the main agricultural and environmental problem worldwide. On the other hand, according to JRI Engineering in the Mining Roadmap 2035 [2] in 2015 around 1.7 million tons per day of tailings were produced and could reach 3 million tons per day in the next decade.

The data collected indicates that wind erosion associated with tailings deposits has not been extensively studied, mainly because the climatic and geographical conditions. high mining production and high number of tailings deposits that occur in the Chilean case, do not occur in other countries. realities with the same intensity, which justified the development of this research. In the Guide to Evaluate EIAs of Mining Projects, experts from the World Alliance for Environmental Law state that the transport of emissions in the air occurs during all stages of the life cycle of a mining operation, the waste piles or deposits contain small particles that can be easily dispersed by the wind. [3]

To define that a tailings deposit is being affected by wind erosion, it is usually enough to observe the place and determine if the wind raises dust or not, however, this is not enough to determine the magnitude of the problem and the measures that must be taken to reduce it, so it is necessary to evaluate the effects of wind erosion in a more objective way.

Objectives

The objective of this research was to develop an in-situ measurement system that allows evaluating the emission of particulate matter into the environment due to the wind effect from Chilean mining waste deposits.

Materials and Methods

The methodology used in the development of this research includes different clearly established activities, such as background information collection, definition of the experimental methodology, development of the experimental research with the definition of the experimental field, execution of a test campaign and field measurements, data analysis and conclusions. The execution of the different experimental campaigns and the collection of more information in parallel, allowed improvements to be made to the methodology for evaluating wind erosion in tailings deposits, finally achieving the definitive version, corresponding to the result of this investigation. The investigationscarried out by Cristóbal García et al. [4] and Asunción Romero and Gregorio García, et al. [5], made it possible to demonstrate the difficulty of developing

technologies to measure particles carried by the wind in tailings deposits and stop I manifest the importance of developing methodologies that allow studying the effects that wind erosion has on different areas impacted by the dumping of mining waste, in order to determine the possible impacts, mitigation measures, definition of land use, among others. The mechanics of wind erosion, understood as the event through which the removal of surface material by wind action occurs, which causes an effect "in situ" and others in surrounding regions, allowed to identify the types of transport that can suffer the tailings particles when affected by the wind, such as rolling, saltation and suspension (respirable particles and settleable particles). This led to the identification of parameters associated with the emission of particles in different situations, concluding that indicators such as breathable particulate matter, settleable particulate matter, saltation matter, wind speed and direction, allow identifying and quantifying the impacts produced by wind erosion in tailings deposits. With this background, different techniques for measuring this phenomenon were investigated and the application of each of them to tailings deposits was analyzed, which allowed the design of integrated tests for in situ evaluation of wind erosion in tailings deposits. Of the investigated techniques, the measurement systems that were used in the investigation contemplated:

I. Erosion pickets, which allow determining the variation of the surface of the deposit affected by the wind, whether it suffers loss or accumulation of tailings particles, over time. According to the information collected, this technique had not been applied in tailings deposits.

II. Measurement of breathable particulate matter, whose objective is to determine the amount of breathable particles with a diameter of 10 μm (PM10) and a diameter of 2.5 μm (PM2.5), which are present in the tailings deposit at the time of measurement. It is important to indicate that the technique for measuring breathable particulate matter is normally a fixed piece of equipment attached to a meteorological station, a situation that in this case did not meet the requirements of measuring emission at different points in the tailing dam and its periodicity, for which reason it was investigated and a portable equipment that is used to carry out measurements in work environments was identified. According to the information collected, this technique had not been applied in tailings deposits.

III. Direction and speed of the wind, the objective of these measurements is to define where the prevailing wind comes from and what speed it registers. Each time the determination of breathable particulate matter is carried out, the direction and speed of the wind must be determined at each measurement point. According to the information collected, this technique had not been applied in tailings deposits.

IV. Settleable particulate matter, its objective is to determine the amount of settleable particulate matter that precipitates in the tailings deposit. This measurement is carried out according to the procedure established in the ASTM Standard. According to the information collected, this technique had not been applied in tailings deposits [6].

V. Matter in saltation (Leatherman traps, its objective is to determine the amount of particles that the wind mobilizes by saltation and drag on the surface using passive saltation traps, or Leatherman traps. According to the bibliography, there is an experience of its application in the Chilean tailings dam of the Mantos Blancos mine located 45 km northeast of Antofagasta, but no further information is available [7].

One of the main contributions of this research is the adaptation of measurement techniques applied in other areas such as agriculture, livestock, industrial, meteorological, and urban to tailings deposits, developing an integrated wind erosion measurement system, which incorporates different measurement methods to quantify different aspects of wind erosion that affect these facilities.

Results and Discussion

The experimental design raised the collection of information that allows characterizing the study area and the geotechnical characteristics of the tailings, subsequently testing different measurement techniques and the periodicity of tests and measurements. The methodology to characterize wind erosion was developed based on experimental measurement campaigns lasting approximately one year each, applying a dust-suppressing treatment to four hectares of the deposit in operation, with the purpose of controlling the emission of particulate matter and evaluate its effectiveness by contrasting the measurements in areas without treatment and with treatment.

The on-site evaluation was carried out in a tailings dam located in the city of Copiapo, Chile, which is in the operating stage, is very close to inhabited areas and at the beginning of the investigation was being affected by the wind. Three experimental campaigns were carried out, each lasting one year. The dust suppressant treatment was carried out with magnesium chloride in part of the sector affected by the action of the wind, leaving the immediately adjoining areas without the application of this suppressant. The campaigns carried out consider the application of the dust suppressor in the January- February period and then the evaluation of wind erosion during the rest of the year, until the operation process deposits tailings again in the studied sector. (Figure 1(a)) shows the location of the area evaluated during the last measurement campaign carried out and the distribution of the measurement points. The analysis of the results obtained in the previous campaigns made it possible to optimize the evaluation, considering five measurement points.

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The measurement systems that were implemented, see (Figure (1b)), were erosion pickets (C1 to C6 and at each of the five measurement points, dust collectors, breathable particulate matter, wind speed and direction, and traps by Leatherman. (Figure 2) shows a typical monitoring station

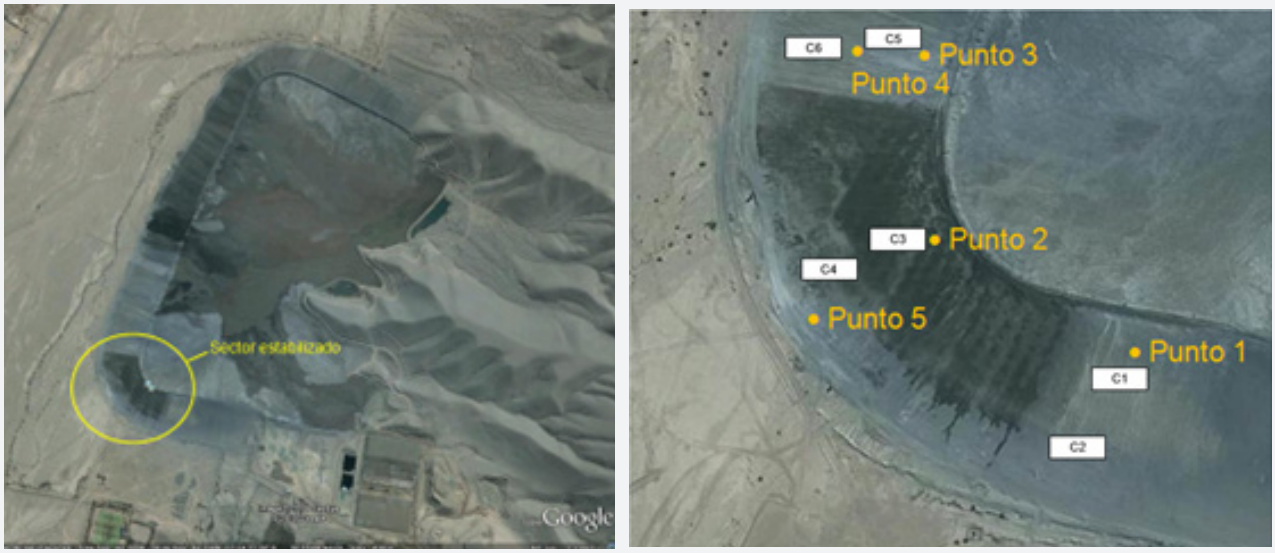

Figure 1: Location of the area evaluated in the third evaluation campaign. (a) Sector evaluated in tailings dam. (b) Location of measurement points.
Taken from: Google Earth.

Figure 2: Monitoring station in tailings dam. Own elaboration.

In the on-site evaluation tests in the tailings dam, the application of the methodology has made it possible to measure the effect of wind action on the tailings dam in operation and to determine the performance of the tailings treated with a dust suppressant, highlighting that the most direct techniques to evaluate this situation are erosion picks and Leatherman traps. However, all the applied techniques, to a greater or lesser extent, show differences in the emission of particulate matter in the tailings deposit between the area treated with dust suppressant and untreated. From all the information generated in it, the following particular conclusions can be obtained.

The results of the measurements of emissions of particulate matter in saltation and rolling, carried out using Leatherman traps, indicate that the traps located in the treated area collected 0.52% of the total material collected by all the traps located in treated areas and untreated from the tailings dam, (Figure 3).

The dust suppression treatment implemented in the tailings dam reduced the emission of particulate matter in saltation and rolling to values greater than 99%, with respect to without treatment, which was determined in all the campaigns in which measurements were made with Leatherman traps. The suspended settleable matter collector, located in the upper part of the treated area, was the one that collected the least amount throughout the measurement period compared to the other collectors, and proportionally collected 12% of the total material collected in the collectors of dust located in the treated and untreated area.

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The dust suppression treatment implemented in tailings dam reduced the emission of particulate matter in settleable suspension to values higher than 85% with respect to the condition without treatment, which was determined in all the campaigns in which measurements were made with collectors of dust (Figures 4).

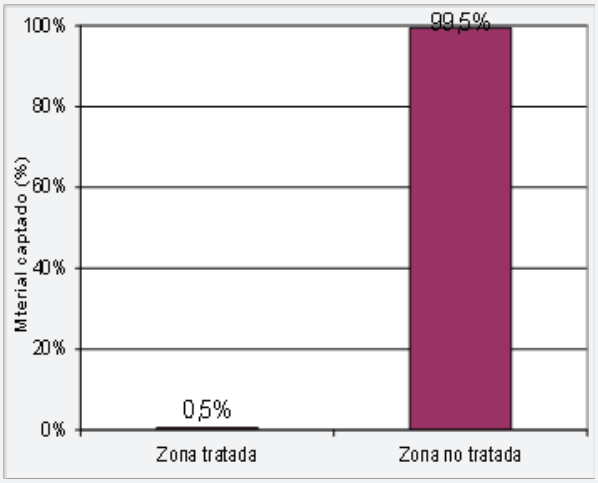

Figure 3: Distribution of the total material captured in the Leatherman traps, according to its location in the area treated with dust suppressant and untreated areas.

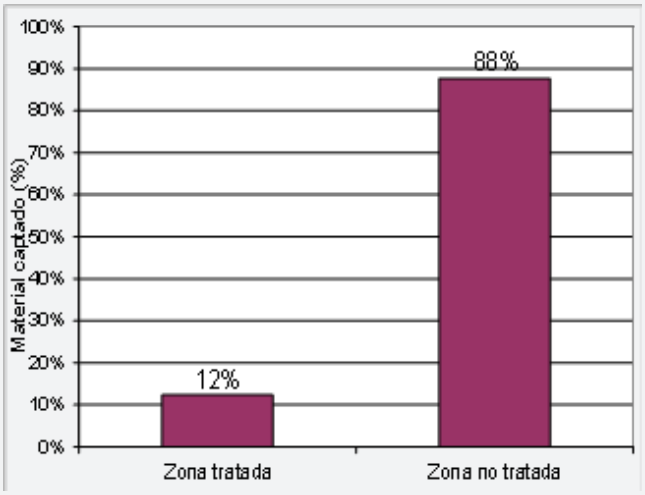

Figure 4: Distribution of the total material collected in the dust collectors, location in the area treated with dust suppressant and untreated areas.

In relation to the measurement of breathable particulate matter of 10 µm (PM10), the monitoring station located in the upper part of the treated area was the one that recorded the least amount during the entire measurement period compared to the other two monitoring stations and proportionally captured 15% of the total PM10 in the treated and untreated areas (Figure 5).

The analysis of the data has made it possible to define variations in the emission of PM10 according to the time of year, registering two periods of the year according to the wind speeds measured, in the period from April to July the lowest wind speeds are recorded and the lowest average emission of (PM10), in the August-March period the highest wind speeds and the highest average emission of (PM10) are recorded (Figure 6).

A variation of 141% has been determined in the average emission of PM10 in the untreated area in the August-March period compared to the April-July period, while in the treated area this variation is 12%, although it registers an increase in the emission of PM10, presents a smaller variation in the emission compared to the period of lower wind speed, (Figure 7). This trend is also observed in the breathable particulate matter of 2.5 µm.

The measurements carried out with the Dustmate equipment have made it possible to demonstrate the effectiveness of the measurement system, allowing the conclusion that the dust suppression treatment implemented in the tailings dam reduces

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the emission of breathable suspended particulate matter to values greater than 80% with respect to the condition without treatment. The analysis of the wind speed and direction measurements have made it possible to make improvements in the operation of the deposit and define the area to be treated with a dust suppressant according seasons with to year, in order to minimize the emission of particulate matter into the environment and other problems associated with wind erosion, such as the stoppage of tailings disposal as a result of dust clouds. The systems implemented have made it possible to quantify the erosive process on the surface of the tailings dam and have been able to demonstrate the effectiveness of the dust suppressant in the treated areas in relation to the situation without treatment.

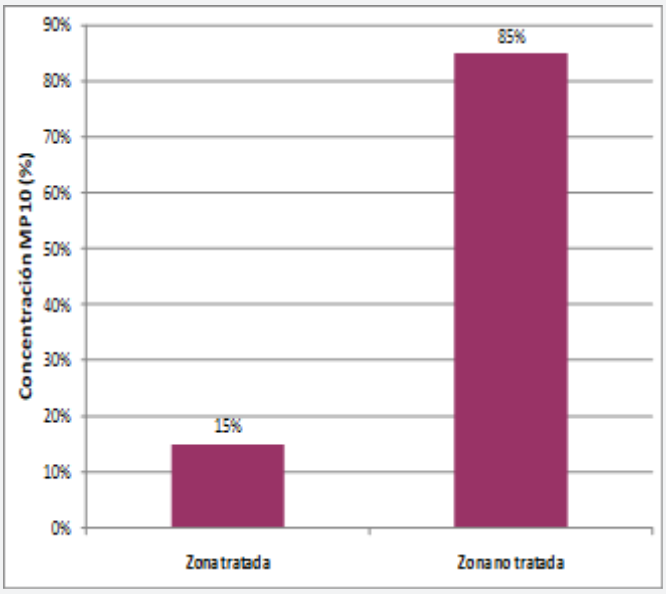

Figure 5: Distribution of total PM10 registered, according to location in treated and untreated areas, tailings dam.

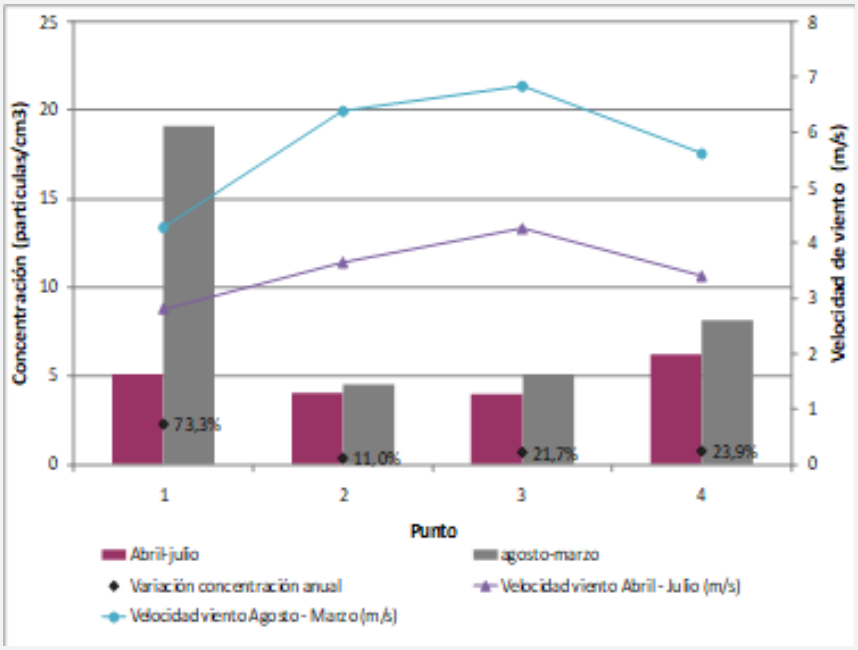

Figure 6: Averages of wind speed and concentration of PM10 and its variation in monitoring stations.

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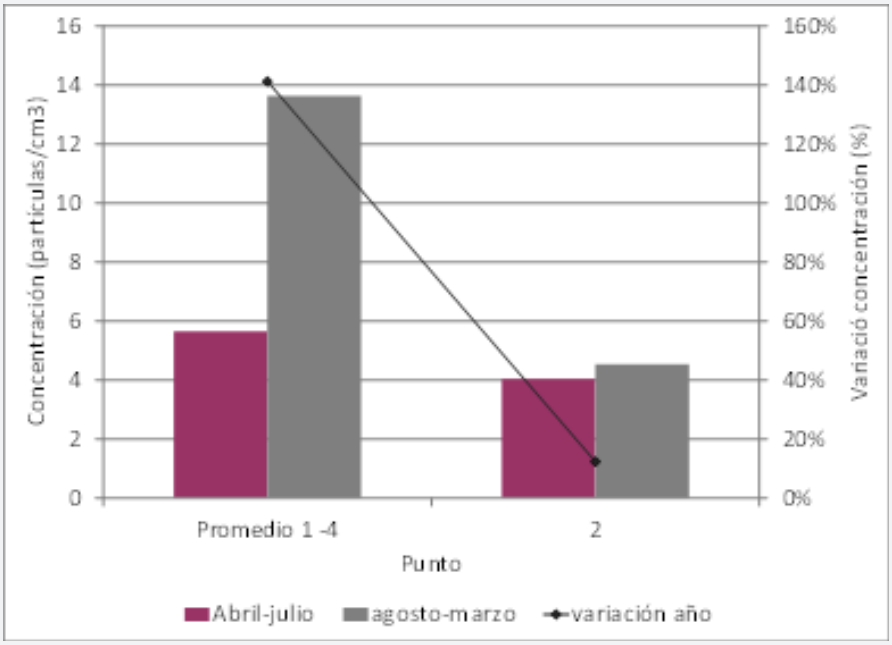

Figure 7: Average PM10 concentration, in treated and untreated areas.

Conclusion

Among the main conclusions of the research, it is highlighted that:

i. The experimental evaluations carried out in situ, within the framework of this investigation, have allowed validating the methodology to evaluate the emission of particulate matter into the environment due to the effect of the wind from tailings deposits.

ii. Having this methodology makes it possible to better solve the problem of wind erosion that affects tailings deposits. The generated indicators are useful in the design process of the recovery measures that are implemented and then in the evaluation of their effectiveness.

iii. It is possible to affirm that compliance with the proposed research methodology allowed achieving the stated objective, since a measurement system was developed that allows evaluating the emission of particulate matter into the environment due to the wind effect from Chilean mining waste deposits.

iv. Among the results of scientific production, it is important to highlight the officialization of the Chilean standard NCh 3266-12 Tailings deposits - Characterization of the particulate matter suppressor product - Evaluation of performance properties of tailings treated with particulate matter suppressor, with which it seeks to provide a tool for tailings deposit managers, supervisory authorities, suppliers of dust suppressant products, among others, that allows them to evaluate the effect of wind erosion on tailings deposits and/or evaluate the effectiveness of the solutions implemented to reduce their emissions [8].

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