Evolution of dust emission control on tailings deposits associated to innovation projects

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INTRODUCTION

• Mining activity in Chile correspond to the main export industry.
• Tailings are a type of waste form by the same material located in-situ in the deposit, in which the valuable mineral has been extracted through the method of flotation.
• In Chile tailings production exceeds 1,000,000 t / day.
• The solution to store them most widely applied, are tailings dams.
• According SERNAGEOMIN, Chile has 493 tailings dams distributed mainly in the northern and central regions. 28% of the total tailings dams are currently in operation and 72% in conditions of abandonment or closure.
• In Chile there are deposits of tailings operation stage or abandonment affected by erosion caused by wind action.
• Wind erosion generates a series of negative impacts on population, environment and operation of mining plants.
AEOLIAN EROSION PROBLEM

Loss of material at the dam as a result of an erosion process and particle dragging (tails) caused by an erosive agent (wind), thus producing mass loss and morphogenetic changes.

Environmental pollution problems
- Characteristics "dust clouds"
- Health risk due to inhalation of suspended particulate matter.

Operational problems
- Deterioration of the top of wall.
- Interruption of operational work.
- Decreased useful life, drag material into the basin.

Slope Stability
- Decreased distance between stored tailings and the top of wall.
- Presence of failure planes due to lack of tailings adhesion with the eroded layers.
- Loss of wall material for grooving.
RESEARCH AND INNOVATION

The research was developed in the FONDEF D00l1101 "Integrated methodology to rehabilitate landfills and tailings dams“ (2001-2004); FONDEF D06l1097 "Development of Technologies for Structural Stabilization Derivatives and Mitigation of Environmental Effects tailings“ (2007-2010) and INNOVA 08CM01-13, “Proposed draft standards for quality control processes operating tailings dams“ (2008-2011) projects. The investigations were carried out by PUCV researchers of the Geotechnical Group, of the School of Construction Engineering, School of Agronomy and Biology Institute, in conjunction with professionals from SALMAG Ltd enterprise.

The research were aimed to develop innovations for the implantation of cover crops and wind erosion control in tailings dams.
RESEARCH AND INNOVATION

To facilitate the implementation of cover crops on tailings, researchers from the PUCV’s Institute of Biology worked on developing a bio-enhancer.

The methodology included the addition of free-living nematodes in the rhizosphere soil and the incorporation of bacteria species (diet) selected from the rhizosphere of selected shrub and trees. The addition of these associations of microorganisms, gives to soil an optimized functionality and dynamic, increasing the fertility.
RESEARCH AND INNOVATION

Between 2007 and 2012, progress was made in the implementation of cover crops on tailings deposits from research conducted in the FONDEF D06I197 "Development of Technologies for Structural Stabilization Derivatives and Mitigation of Environmental Effects tailings“ project.

Biochemists from the Biology Department, University of Santiago, led by PhD. Claudia Ortiz C., developed a research that helped to characterize and obtain parameters of tolerance, adaptation and efficiency indexes for stabilizing tailings substrates with native plant species.

Characterizations of plants for the production of a seed bank using plants with adaptations to extreme environmental conditions (gene bank) were conducted. In addition to characterizations of plants collected to investigate genetic providing tolerance to extreme environments.
RESEARCH AND INNOVATION

The assessment of wind erosion and the effectiveness of suppressive treatment of particulate material in the experimental field was performed using a methodology developed by researchers from the PUCV’s Geotechnical Group from FONDEF D06I197 "Development of Technologies for Structural Stabilization Derivatives and Mitigation of Environmental Effects tailings" and INNOVA 08CM01-13, “Proposed draft standards for quality control processes operating tailings dams" projects, developed between 2007 and 2012.

Results obtained provided important background information on the erosive effects of wind on tailings dams and technologies to mitigate or control emissions of particulate matter.
EROSIVE PROCESS GENERATED BY WIND

The incorporation of a particle to an air stream is product of three main forces:

- Gravity caused by the grain mass (a).
- Thrust or pulling produced by wind (b).
- Suction caused by decompression of the air mass - in opposition to the action of wind, this decompression generates a 45 degrades strength of direction (c).

The transport of the particles is carried out by:

- **Suspension.** Raise particle diameter less than 0.1 mm.
- **Saltation.** Elevation of particles and subsequent collision with other particles, on the ground.
- **Surface Creep.** Caused by the energy derived from smaller grains, which descend and saltation impacting to larger grains.
EROSIVE PROCESS GENERATED BY WIND

The particles moved by the wind through suspension, saltation, and surface creep may be deposited in different places when the velocity of the wind decreases.

This is a continuous process of selection and deposition of different-size particles, and the velocity of the wind plays a key role in this process.

The threshold fluid velocity is the minimum speed at which the phenomenon of saltation begins to produce.

Impact velocity threshold corresponds to the wind speed required to maintain the process of saltation.
EMISSION CONTROL OF PARTICULATE MATTER

- Tailing Dam N° 3 of the M.A. Matta Plant ENAMI, Copiapó. Operation started in 1987; “downstream” construction method; classification of tailings through lined-up hydrocyclones.

- Hexahydrate magnesium chloride hexahydrated (MgCl₂-6H₂O) Stabilizer is produced in the Atacama Salt Flat in Chile, involves alloying properties, high hygroscopy, deliquescence, evaporation resistance, freezing temperature equal to -32.8 °C and high solubility in water.

- In situ Assay: 2 Ha were stabilized using a proportion of 3 kg/m²; 12 measurement fields were installed in treated and untreated areas.
EMISSION CONTROL OF PARTICULATE MATTER

- *In situ* measurements

- Results of *in situ* measurements
ASSESSMENT SUPPRESSIVE TREATMENT FOR PARTICULATE MATTER EMISSIONS

NCh3266-2012 Tailings Deposits - Characterization of particulate matter suppressant - Evaluation of performance properties of tailings treated with particulate matter suppressant

Scope and applicability

• Establishes conditions and documentation must have of particulate matter suppressant used in tailings surface treatment.
• Establishes procedures for evaluating performance properties of tailings treated with particulate matter suppressant.
• Does not apply to suppressors requiring intimate and homogeneous mixtures, with the tailings to be treated.
• Does not consider the use of cement and asphalt products.
Suppressant of particulate matter

- Consider a wide variety of kinds, among which are salts, enzyme products, polymers and petroleum products.
- They are designed to modify the tailing by a slight cementation of the particles or forming a surface layer.
- They can have effects on one or more properties of tailings performance, according to the specific type and application conditions as well as the characteristics of the treated tailings.
- Must be accompanied by, informative Manual and Safety Data Sheets (NCh2245 - NCh2353) and be marked and labeled (NCh2190).
Tailings performance properties

- Are evaluated by comparing the results of evaluations performed in situ or in the laboratory on untreated tailings and tailings treated with suppressant of particulate matter.
- The treated tailings performance generally depends on conditions such as: intensity of the application; dilution ratio; frequency of application; interaction with the tailings; atmospheric and climatic conditions; Wind speed and direction; time of incidence of the wind; features of tailings; geometry of the tailings dam; and operating conditions of the deposit.
- Some of the assessments or tests specified in this standard can be applied to untreated tailings or tailings treated.
- The performance properties to consider are associated to the control of particulate matter emissions, which includes: respirable particulate matter (PM10 and / or PM2.5); settleable particulate matter; and mobilized material by surface creep and saltation.
ASSESSMENT SUPPRESSIVE TREATMENT FOR PARTICULATE MATTER EMISSIONS

Assessments and tests

• Before assessment performance properties of tailings, geotechnical characteristics are determined and classified.
• The laboratory assessment of the performance of tailings is done by determining the mass loss in specimens tested with and without suppressant of particulate matter. This feature is determined in a wind tunnel.

The in situ tests include evaluation of particle transport by:
• saltation; 0.1 mm to 0.5 mm in diameter;
• surface creep; 0.5 mm to 10 mm in diameter;
• suspension; less than 0.1 mm diameter (very fine sand, dust and respirable particles (PM10 and PM2.5).
CONCLUSIONS

The research developed by the Geotechnical Group PUCV have allowed the development of innovations and contributions as:

• development of technologies based on chemical suppressors of particulate material to minimize erosion problems caused by the wind during the operational stage in tailing dams.

• technology development, based phytostabilization to minimize erosion problems caused by wind action during the abandonment stage in tailings dams.

• development of NCh3266-2012 standard, which contributes to the generation of operational guidelines, recommendations and optimizing treatments suppressor particulate matter emissions, tailings deposits in operation or abandonment stage.

• the technologies are extendable to other deposits with similar characteristics as those of massive mining waste or industrial waste such as fly ash and slag from coal combustion, which also require decrease environmental impacts and optimize costs in both stages of operation as abandonment.
CONCLUSIONS

From these developments, the company Salmag Ltda., implemented a new service called Emag, to control wind erosion on tailings dams and other similar facilities.

Also the research and innovation, have prompted researchers to create new companies applied engineering services such as:

Ambiotek SPA ([http://ambiotekspa.com/ambiotek/](http://ambiotekspa.com/ambiotek/)) spin off University of Chile Santiago (USACH), whose mission is develop and commercialize of environmental solutions for the remediation and revalorization of environmental liabilities, primarily focused on copper mining. Born in early 2011 as a company to capitalize on the results achieved by research in phytotechnology, made by the USACH with CODELCO. Its CEO is Dr. Cs. Bio. Claudia Ortiz C.

Geotecnia Ambiental Ltda. ([http://www.geotecniaambiental.cl](http://www.geotecniaambiental.cl)) is recognized as a company that provides comprehensive, high-quality solutions, primarily in the Mining, Energy, Construction and Solid Waste. It is a limited company that was formed on December 16, 2004, whose founder and CEO is Dr. Ing. Raul Espinace A.