PROMETHEE days 2020

e-Rabat, Morocco, June 2-5, 2020

The role of multi-criteria decision analysis in public policies for the management of tailings dams

Vinka Monardes [1,2]
Rodrigo Barraza [1,3]
Juan M. Sepúlveda [1]

[1] University of Santiago, Santiago, Chile
[2]University of Antofagasta, Antofagasta, Chile
[3] Santo Tomás University, Santiago, Chile

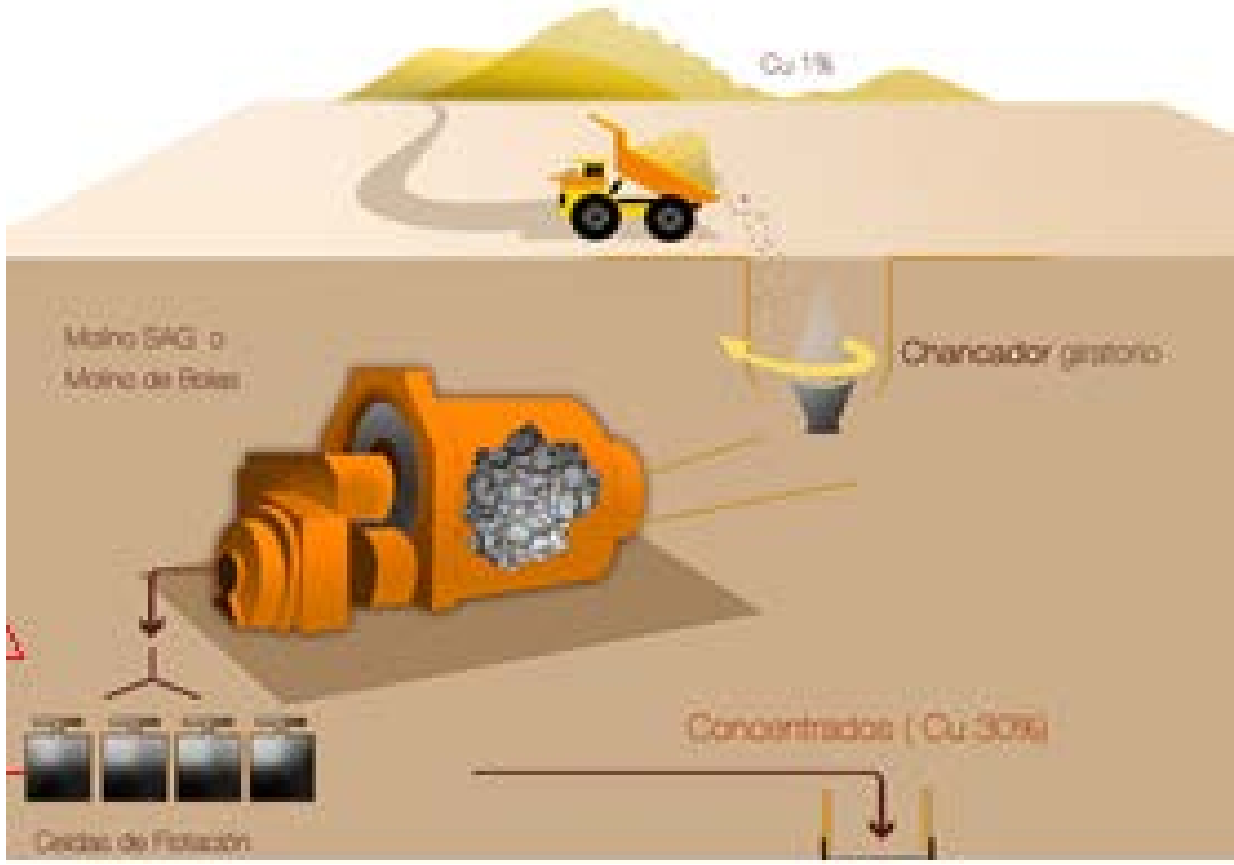
PROMETHEE Days 2020 Rabat, Morocco, Jun 2-5, 2020

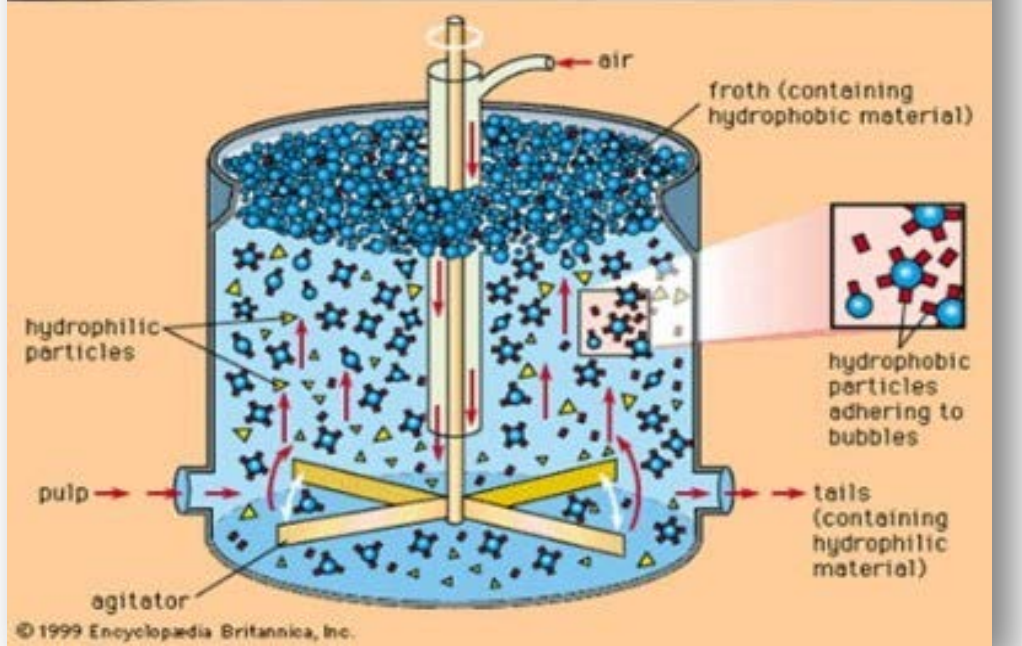
1. Introducción

In the copper deposits the mineral is extracted either as sulfide or oxidized copper.

<u>Copper sulfide process</u>

- The process begins with the extraction.
- It undergoes a crushing process.
- They go to grinding to enter the mineral concentration process.





Mineral concentration process

- Flotation cells are used.
- Floating is a selective separation process.
- The “tailings” is the discarding of the flotation process.
- The “tailings” is transported to a tank away from the facilities.
- In the case of Chile, an amount greater than 95% of the processed ore becomes the tailings.

- Tailings dams are large deposits.
- The mineral tailings can contain varying amounts of different elements that can cause damage to human and / or environmental health, such as arsenic, cadmium, mercury and others.
- The risk of damage can be even greater for mineral processing tailings from older operations, since metal recovery rates were generally much lower than modern operations.

2. The situation of tailing dams in Chile

- Chile ranks first in the world in copper production, this is equivalent to 28.3% of the world production.
- Tailings are spread in sectors of many smaller sites, which does not necessarily imply a greater material volume.
- In 2018 (Sernageomin), in Chile, there are 2 different types of deposits, these are: Tailings dams, with 81.05% of the total (603 deposits) and Tailings Reservoirs, with 15.99% (119 deposits).

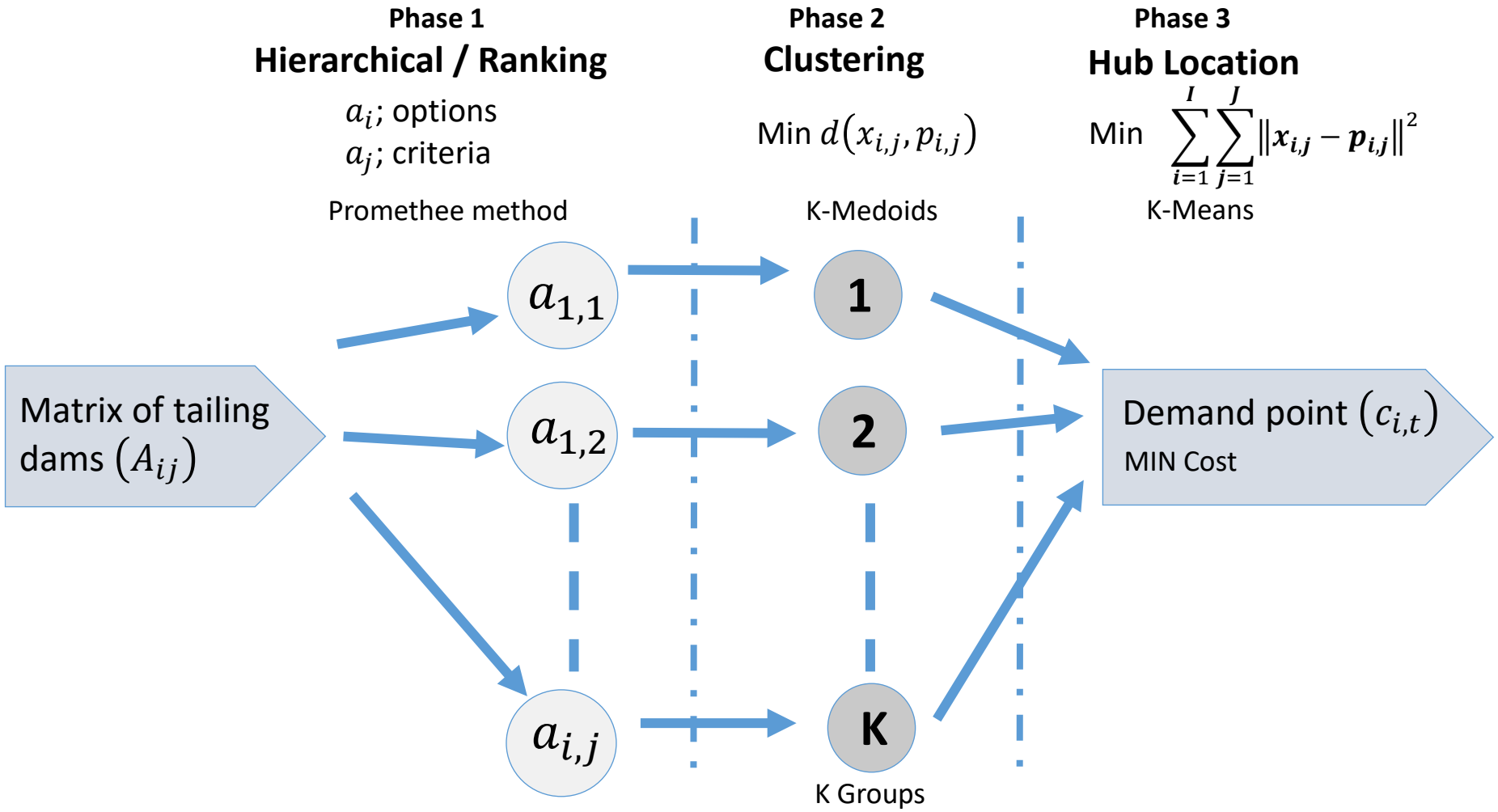
- The tailings deposits are works structured in a secure way to contain the tailings, but the fundamental problem lies in the eventual failures of the measures to safeguard the mining waste through time.
- In addition, there exist abandoned tailings deposits, since at the time they were formed, there were no environmental regulations on this issue.
- It should also be considered that in Chile, there are strong earthquakes and that it is a long territory with a very close coastal mountain range (they can cause landslides).

3. Case Study

- The largest amount of tailings deposits are from the Atacama and Coquimbo Regions.
- The case was developed finally with 101 tailings dams located in the Coquimbo Region, having the 61,3% of the abandoned tailings (106) out of a total of 173 in the country. The “Abandoned” category counts for the 23% of the total number of tailings dams and deposits.
- The databases used in the case study correspond to the data obtained from strategic technological programs managed by the Chilean government for the recovery of elements of value in tailings deposits.

- The proposed approach from the industrial engineering viewpoint is the installation of recovery plants near the sites where the tailings dams are located.
- The 101 tailings dams classified as “Abandoned” were prioritized by using the Promethee method as Phase 1 of the study.
- Promethee is the first step of the proposed solution for the hub-location problem. The next phases were algorithm K-medoids for clustering and K-means for final location.
- Promethee ranking was input data for the clustering algorithm.

Methods


Phase 1
Hierarchical / Ranking
a_i; options
a_j; criteria
Promethee method
Phase 2
Clustering
Min $d(x_{i,j}, p_{i,j})$
K-Medoids
Phase 3
Hub Location
Min $\sum_{i=1}^{I}\sum_{j=1}^{J}\|x_{i,j} - p_{i,j}\|^2$
K-Means
Matrix of tailing dams (A_{ij})
$a_{1,1}$
$a_{1,2}$
$a_{i,j}$
1
2
K
K Groups
Demand point $(c_{i,t})$
MIN Cost

Chemical elements of interest (in red)

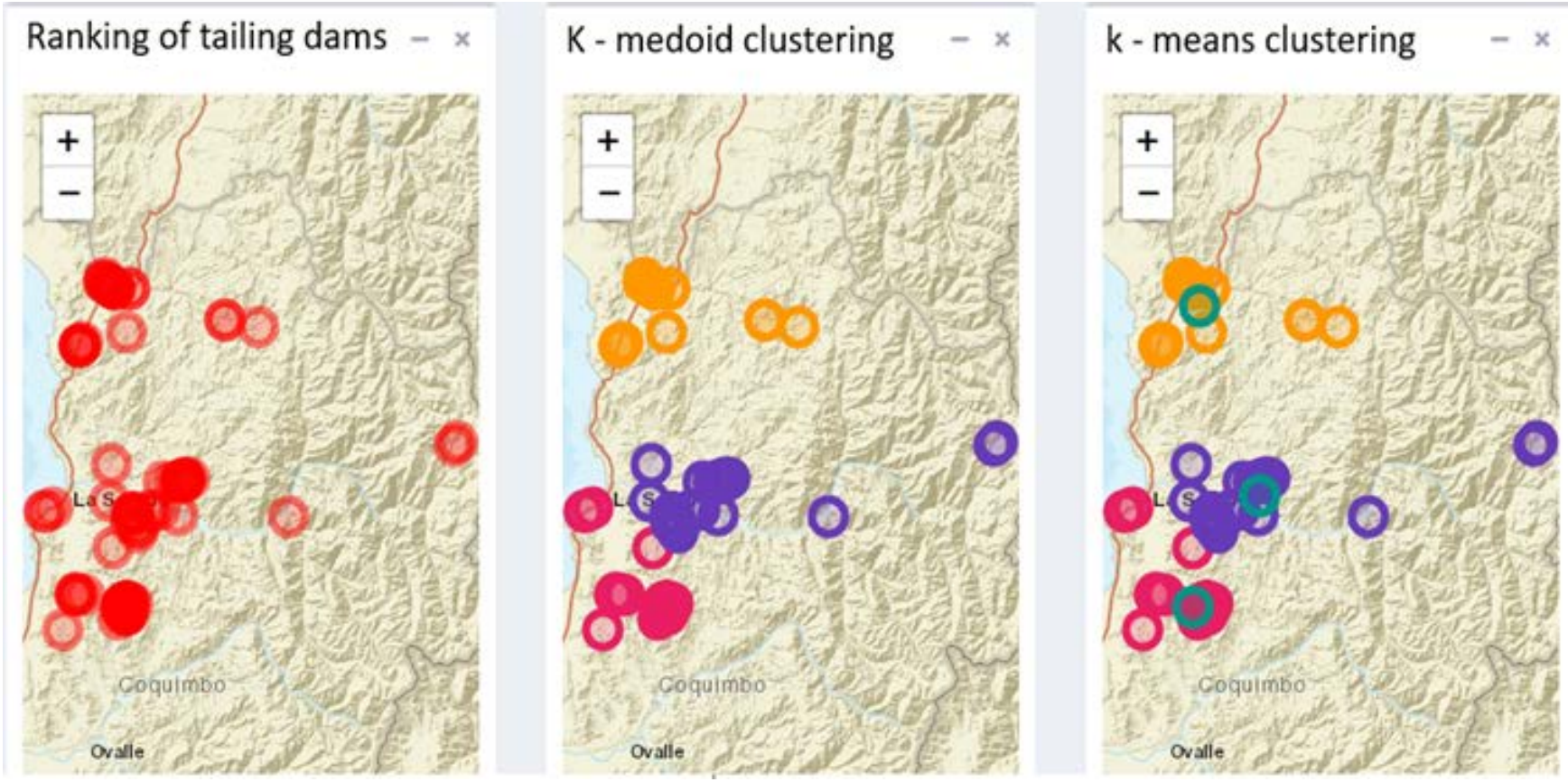
Cu	Zr	U
V	Nb	As
Cr	**Ba**	Mo
Co	**Pb**	Sb
Ni	Sc	Sn
Zn	Cs	Ag
Rb	Hf	Cd
Sr	Ta	Bi
Y	Th	W

Sernageomin database contains characterization of tailings (grams/ton, Vol., %)

Summary case study settings

Parameters	Value
Number of tailing dams	101
Number of criteria	6
Promethee Variables (g/t) (m^3)	Cu; Zn; Ba; Pb; V; Volume (m^3x10^6)
Weight of criteria	1/6
Preference function	Usual
Quantity clusters	3

The type of results from the three phases



Phase 1 Phase 2 Phase 3

4. Conclusions and Further Research

- In this study was shown the usefulness of PROMETHEE as a strategic decision-making tool.
- The output is reliable information to guide public policies and to orientate private companies where to put their efforts thinking in a sustainable production model.
- The decision criteria and parameters considered may be adapted to any case where a mining company wants to achieve an efficient interaction of the transport of tailings with the location of a reprocessing plant.

5. Further Research

- The initial ranking obtained from the first phase in the PROMETHEE method may have a smoothing in terms of the hierarchy obtained by using other preference functions.
- Other criteria related to sustainability issues may also be included, such as impacts on communities nearby, water resources, agriculture, wildlife.

The role of multi-criteria decision analysis in public policies for the management of tailings dams

Thank very much for your attention

Muchas
GRACIAS