Luis Bernal Venegas
Consultor Externo de procesos
A-S CHILE EGSA
+56-979577770

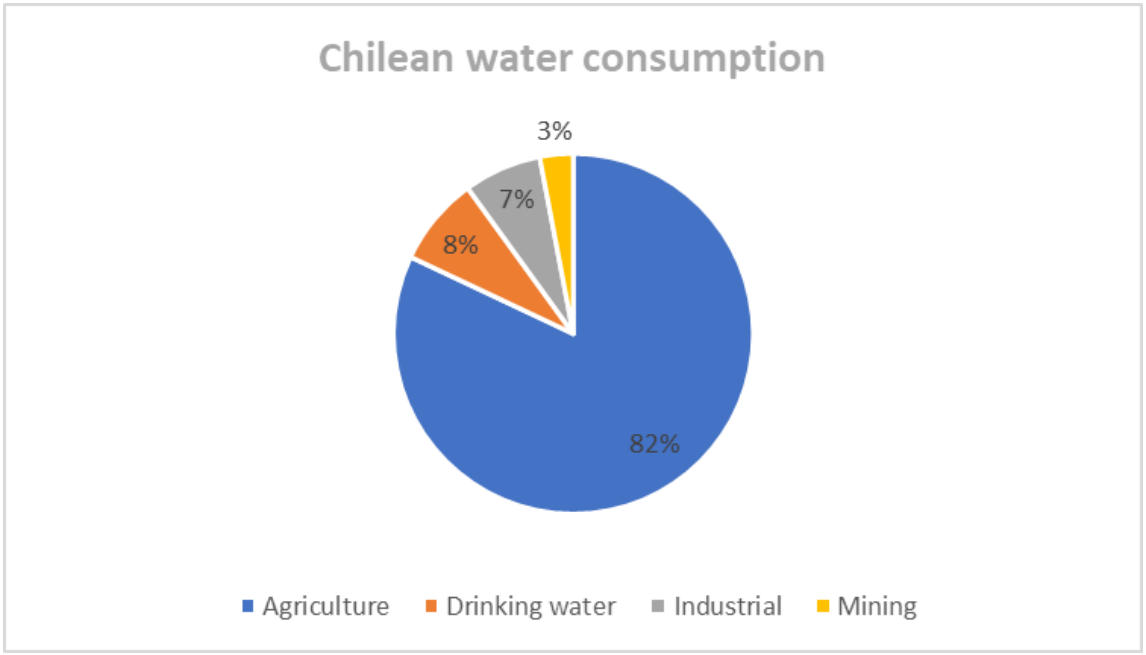
Strategy to reduce water consumption in concentrator plants

By Luis Bernal, Process Minerals Consulting

Restrictions for water use in mining

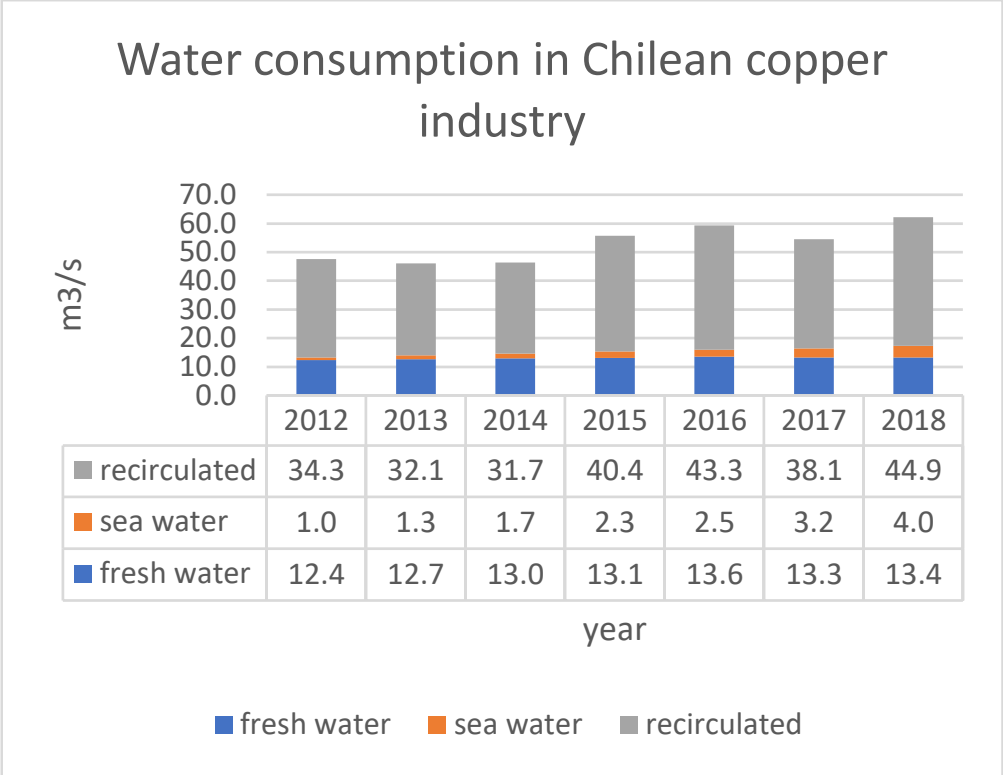
2019 was one of the driest years in Chile, and as in the rest of the world, not only the population is directly affected but also industries, including mining, which is one of the most important sectors for the development of this country. In this context of water scarcity, the mining industry faces limited water resources and increased costs, therefore what can mining do to reduce the consumption of fresh water in its operations?

According to a statistic by the DGA (Chilean Water Department), during 2016 the mining industry consumed 3% of the country's fresh water resources. Although this is a low percentage of the total, the amounts of water used are relevant in a scenario of scarcity and to face the need to develop new projects:



Source: Chilean water consumption, DGA 2016 (page 125)

In the last decade there has been a moderate tendency to replace fresh water or inland water with seawater resources and a stronger policy to optimize water recirculation in processes. The following is the total water consumption in copper mining between 2012 and 2018 in m^3/s at its main sources, reaching 13.4 m^3/s in copper and 15 m^3/s in total with other minerals:



Source: Cochilco 2019 (Chilean Copper Commission)

Cost of fresh water, seawater and desalinated water

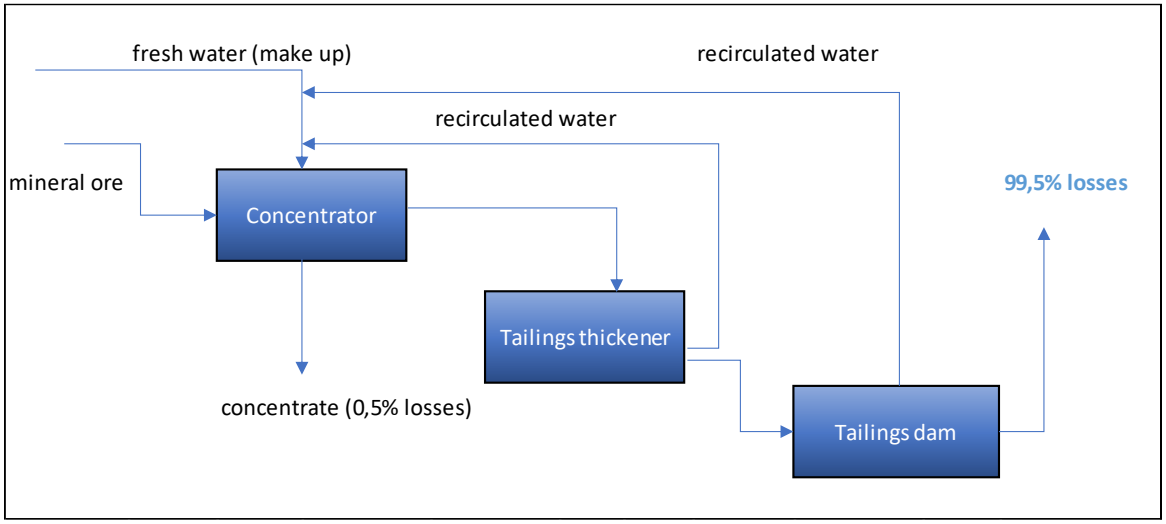
The operational cost of fresh or continental water is very low, in the order of 0.3 to 0.5 USD/m^3, since they are usually gravitational sources of the high mountain range or well pumps close to plants. Nevertheless, given their scarcity and environmental impact on glaciers, salt flats and groundwater, there has been a replacement for raw or desalinated seawater. The cost of treated desalinated water at a reverse osmosis plant is around USD 1.0/m^3, but considering that the concentrator are in the mountain range at an altitude between 2,000 to 4,000 m.a.s.l., the final cost reaches 3.0 to 5.0 USD/m^3 per pumping stage. So that being a strategic, scarce and high cost resource, miners are developing strategies in concentrator plants to reduce water consumption (makeup water).

Concentrator plant water balance

It is necessary to know the water balance in a concentrator plant to identify where the losses occur, which are ultimately water consumption. This consumed water must be replaced, and this concept is called makeup water.

The diagram below represents the balance of a copper concentrator plant with the conventional tailings technology. It is observed that 99.5% of consumption corresponds to losses that occur in the tailings dam. The water loss in the concentrate, corresponding to the moisture of the product, is only 0.5%. For iron ore concentrator plants whose product mass yield is higher, the water consumption in the concentrate increases to 15% and in

the tailings decreases to 85%. In both plants the water consumption in the tailings is high, so it is necessary to check the water losses in the tailings if we want to optimize the water consumption.



Ref. Copper concentrator water balance

Water losses in tailing deposits

Understanding that water consumption depends mainly on the water that is lost at the tailing deposit stage, it is important to review the deposit methods used and the water consumptions (makeup) associated with each technology, which are basically divided into three processes:

Conventional tailings dam

Conventional tailings consist of a dam or wall that closes a valley, constructed of sterile ore or sands classified from the same tailings stream, to delimit a deposit volume that reaches millions of tons. Tailings with 50% to 60% solids are deposited in the tailings dam, where 20% to 30% of the water transported is recovered. Afterwards a clear water lagoon is formed.

For a common concentrator plant of the several existing ones in Chile with a capacity of 100 ktpd and a life of mine of about 20 years, the expected volume is to contain 720 Mt of tailings equivalent to 480 Mm^3, containing a significant amount of water that is lost due to three causes: 15%-20% in evaporation of the water lagoon and the wetted active beach, 10%-15% lost by infiltration and 65%-75% is water retained in the fine tailings, mainly in the slimes and ultra-thin material.

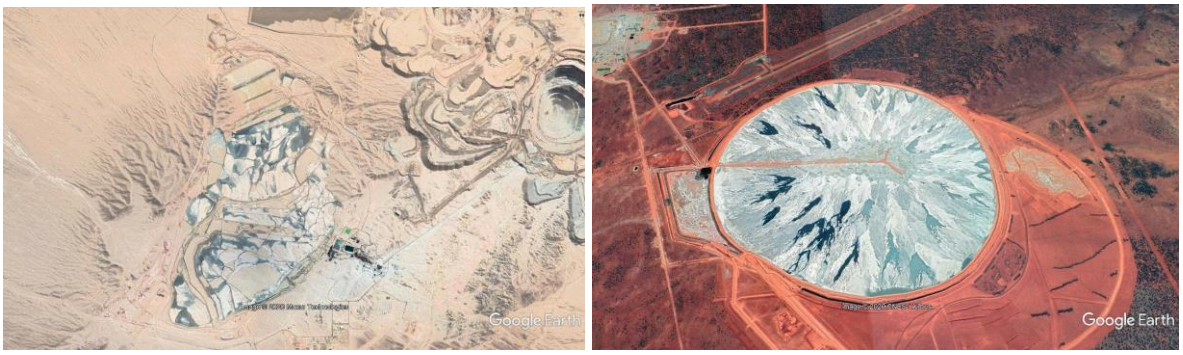
Ref. Relaves convencionales

A plant of this type, depending on the topography to locate the dam and the zone evaporation rate, typically high in northern Chile, can have a makeup of 0.35 m^3/t in the case of plants that have advantageous topographic conditions. The average consumption of a tailings dam with 30% water recovery from the clear water lagoon is 0.60 m^3/t with a water consumption of 700 lps.

Considering the distribution of the indicated losses, studies should be conducted to reduce the loss of water retained in the deposit by fine particles (65%-75%) and increase the recirculation of recovered water to the plant.

Paste and/or thickened tailings

The paste and/or technically thickened tailings correspond to unsegregated tailings that due to their high viscosity under optimal conditions, must operate without generating a wastewater affluent. They receive tailings with 60% to 70% solids produced in high density thickeners, equipment of deep angle cone to be operated with high yield stress, whose values range from 100 to 300 Pascals, which need high drive torque from 6.0 to 10.0 MN-m and thickeners of diameter not more than 45 m.



19999

Ref. Paste/ Thickened tailings

The water consumption to replace water discharged by pulp with 70% solids corresponds to a makeup of 0.43 m^3/t. Once in the tailings deposit, it is not possible to recover more water, although in some plants that do not reach a percentage of solids or sufficient viscosity, the tailings generates a recoverable drainage of 5%-10% of the total water entering the deposit.

Filtered tailings

Filtered tailings are obtained using high-capacity filters, usually high-pressure filters, due to the difficulty of filtering extremely fine particles such as ultra-fines or clays. Initially they were used in small capacity plants and currently there are plants up to 40,000 tpd using this type of technology. Once generated, the filtered cake uses a system of belts and stackers to generate a dry stacking system of several layers of 6m to 10m until reaching heights of 100m.

Ref. Relaves filtrados

Slurry coming from thickeners with 50% solids is fed to filters, where their moisture is reduced to 20% equivalent to 80% solids. As a result, the water consumption or make up decreases to 0.25 m^3/t, being more efficient compared to other technologies. The disadvantage is the high cost of the filtration equipment and the stacking difficulties for fine materials producing high moisture content.

Water efficiency technologies

- ***Increase concentration of thickening solids***
  The thickening stage modernization, which is present in all three tailing deposit technologies, is related to the implementation of automatic control systems, and by in-line instrumentation of the clear water and sludge level, such as SmartDiver equipment used in all types of thickener, as well as with the use of rheological reagents that allow higher thickening rates, without increasing the viscosity of pulps for application in paste/thickened tailings.

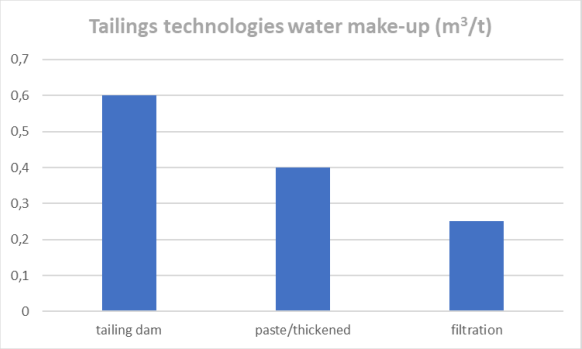
- ***Increase water rate recovery in conventional tailings dam***
  Use of special reagents to achieve post-decanting of ultrafine tailings in the reservoir, control of lagoon volume over time and improving the measurement of evaporation rate on active beaches and in the lagoon using satellite technology.

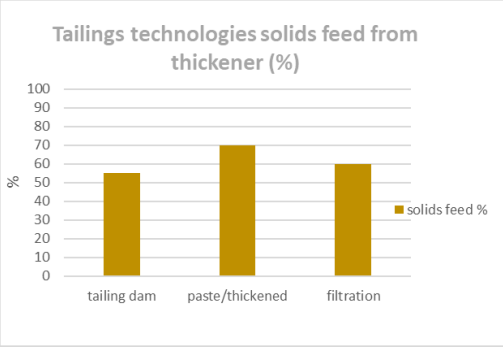
- ***Increasing capacity of filter***
  The objective of this strategy is increase equipment size to diminishing the opex and capex to apply this technology in bigger concentrator, such as those over 100 ktpd.

- ***Replacement of fresh water with seawater***
  From the use of desalinated water in Minera Escondida (BHP) in 2006 with a desalination plant of 525 lps in 2006 and after the use of raw water in the Esperanza project (AMSA) of 95 ktpd in 2010 with a 700 lps pumping lifting plant at an altitude of 1800 m.a.s.l. and one 150 km pipeline, seawater use has increased from 0.98 m^3/s 2012 to 4.0 m^3/s 2018, currently corresponding to 30% of total water consumption in copper mining, and is expected to continue to grow. Currently several projects are under construction to use desalinated and raw sea water to feed 500 ktpd in total processing capacity. Considering a makeup 0.6 m^3/t, the projects are to supply 3.5 m^3/s, nearly duplicating current consumption.

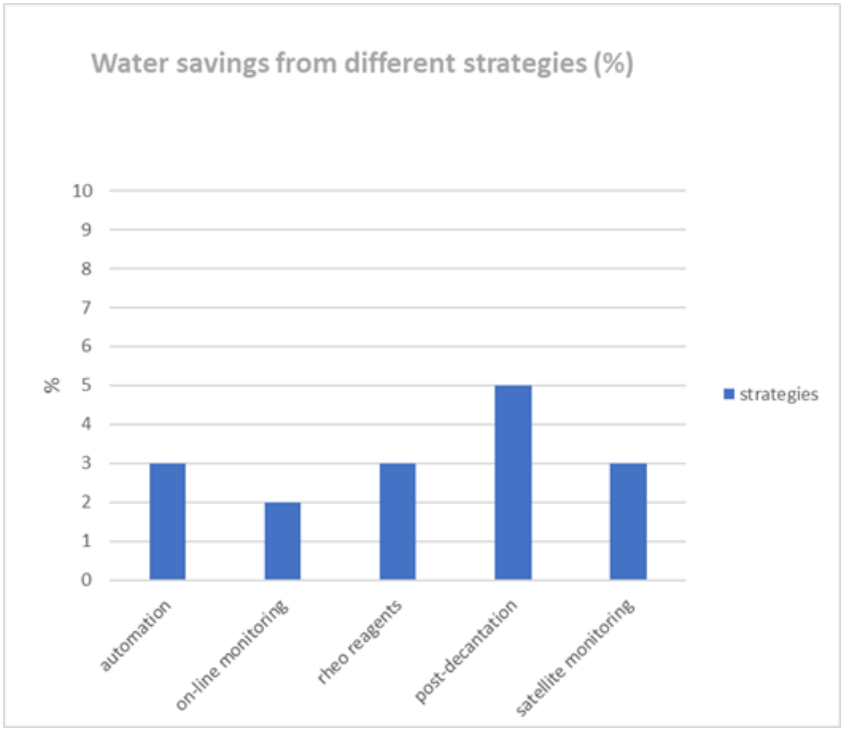
Summary

Water consumption or make-up in a concentrator plant depends essentially on the deposit technology used, also the three deposit technologies must use thickeners that feed the tailings with different concentrations of solids to the conventional dam, paste deposit or feed a filtration plant, as is presented below:





The strategy and technologies aimed at reducing water consumption are automation, thickener in-line monitoring, reagent development, satellite technology for monitoring active beach and lagoons, and replacing fresh water with desalinated water or salt water from the sea. Besides, development of projects of paste/thickened tailings and filtration are overcoming conventional tailings dam not only for the water consumption but also for environmental and sustainability issues. Expectation of savings ranging from 2% to 5 from different strategies are presented in the next graph, as their development continues for conventional and paste/thickened tailings:



LB/oct 2020