Mine water management in abandoned mine sites: from waste to resource

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Abstract
Text Mine water usually supposes one of the most important environmental problems of the extractive industry, where water quality is dependent of a great number of factors relatives to the ore deposit characteristics and to the exploitation method typology. But if water quality by nature or after convenient treatments stays inside the acceptable limits, according to the legislative quality standards, mine waters could be used for different uses. Then, new studies on the framework of the circular economy paradigm have led to found new possibilities for mine water, which in some cases can be considered as a potential water resource, generating new economic activities in the mining regions.
Keywords: Mine water, water quality, water resource, circular economy

1. Introduction

The role of mining is very significant in the current globalized economy, so pioneering and sustainable post-mining technologies to reduce environmental impacts and to intend generate new resources are demanded.

The underground mining requires shafts and extensive galleries to exploit the mineral resources. Then, mine voids together with the fracturing in enclosed rocks induced by mining operations are filled up with water, which must be pumped in order to develop the mining operations for exploitation of the ore resources.

Water quality is dependent on a number of factors, including the oxygen status of the void, pH, hydrogeological flow system, composition of wall rock and concentration through evaporation and biological activity. Then, a compromise between the extraction of mineral resources and the environmental protection is possible and this must be reached in the framework of the applicable normative, taking into account the particularities of the mining activities.

2. Methods

After long periods of mining activity, the created mine voids and the effect of the induced fracturing on the enclosing rocks induce important changes into the hydrogeological parameters of the area. The values of porosity, permeability and transmissivity increase significantly from their initial values, so the mining and the associated fracturing creates a new hydrogeological system.

Under these conditions, when the extractive activity in the mines ceases, perpetual costs related to pumping to keep a safe water level or water treatment have to be maintained at significant cost if water quality does not inside the legislative quality standards, these facts constitute a large economic burden on current and future generations and the mine can become long-term liabilities (Pendás and Loredo, 2006).

If the pumping operations are interrupted, a recharge by infiltration causes the flooding of mine voids, creating a new “aquifer” with a triple porosity (intergranular pores, fracture spaces, and mining voids for drifts and exploited layers), as results of the connection between voids (galleries, chambers, beds, etc.) and fractured host rocks induced by mining operations, and this new aquifer behaves similarly to the karst carbonate aquifers.

Then, closured and flooded mines constitute underground mining reservoirs, which in order to be used for potential applications, it is essential to define the water quality, the hydrogeological model, the water balance, and the volume of voids of the mining reservoir system previously to these applications, which fit with an integrated management of water resources, allowing regulating simultaneously both surface and underground resources.

3. Results

Mine water, either coming from the pumps over the life of the mine, or from the stage rebound during the closure period could be used with economic and social benefits for different applications if it is properly treated and managed. The potential use of mine water, either directly when it is not affected by acidification or other contaminants, or after treating them by active or passive treatment systems in order to bring their quality to that required by the quality standards, can be reused for

industrial processes, and as an additional resource for agriculture, particularly during periods of extended drought. The use of mine water as resource in these fields allows minimizing the consumption of the conventional water resources, which is especially important in times of water stress or climate change.

Besides, it creates a link to help to alleviate any possible friction between farmers and mining companies concerning the use of water. In these cases, the use of mine water can serve as mitigation in the event of a drought, and it can cut off the supply for irrigation of agricultural products of water high consumption. Then, a convenient regulation of the underground dam could have a strong impact on the water supply of the zone, which is especially important in periods of water stress, when the underground mine water reservoir could be regulated and used as water and energy resource (Ordóñez et al., 2012).

Innovative technologies for sustainable post-mining solutions include the geothermal use of mine water and the pumped energy storage using the mine infrastructure, taking advantage of the deep mine shafts and voids, and the pumping installations (Loredo et al., 2011; Jardón et al., 2013).

The use of mine water from underground mines to generate electricity using the difference in heights between the sublevels o between a sublevel and a surface deposit as natural waterfalls; lower levels would be transformed into receptors or secondary dams, where they would receive turbined water (Menéndez et al., 2018). The operation system would be similar to the double reservoir, currently employed by many countries for hydroelectric use, generating energy at times of high demand and pumped water at times of low demand. Another potential use for mine water is its consideration as a geothermal resource for urban and industrial installations. The development of energy production projects in abandoned mines has a positive impact on depressed mining districts due to the closure of mines, with the creation of new stable jobs.

4. Conclusions

In the framework of the extractive activities mine waters are usually considered as a big environmental problems, but into the paradigm of a circular economy they could be considered as a resource depending of their physicochemical characteristics. In this context if they are properly treated and managed, mine water can be used with environmental, economical and social benefits, and potential uses could be: Industrial, agricultural or ecological activities, protecting the river systems by preventing in overexploitation under the consideration that the mine water constitute a big underground reservoir, production of low enthalpy geothermal energy, and others such as industrial, agricultural or ecological activities, or for production of renewable energy. Then, mine water, either coming from the pumps or from the stage rebound after flooding during the closure period, could be used with economic and social benefits.

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