

RISK ASSESSMENT AND MANAGEMENT OF WATER IN MINING INDUSTRY BY WATER TREATMENT & RECYCLING OPERATIONS

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ABSTRACT

Water plays a critical role in mining operations, both as a vital resource and as a source of challenges with significant environmental and economic implications. Mining activities often intersect with groundwater and surface water systems, leading to large-scale dewatering processes that can lower water tables, destabilize rock masses, and generate substantial volumes of wastewater. Improper management of these waters contributes to hydrological disturbances and intensifies water scarcity issues in surrounding regions. This study highlights the interrelationship between mining and water resources, focusing on the risks arising from uncontrolled mine dewatering. It further emphasizes the importance of adopting effective water management strategies, particularly through treatment and recycling operations. Such practices not only mitigate environmental impacts and enhance the stability of mining areas but also promote sustainable water use by replenishing local water levels. The findings reinforce that integrating water treatment and recycling into mining practices offers benefits beyond the industry, providing valuable water resources for surrounding communities and contributing to long-term environmental sustainability.

Keywords: Mine water management, Dewatering, Water treatment, Recycling operations

1. INTRODUCTION

Vital for many of the relevant processes and operations, but also a source of problems and major additional costs. These problems often occur because mining takes place under the water table level, and superficial waters are also involved to a greater or lesser extent. A consequence is the need to drain water from mining sites, often times at significant flows resulting from the development of broad drainage cones that must be maintained throughout the mining operation; and sometimes at lower flows that greatly enhance stability conditions of the rock mass. This causes hydrological, environmental and economic effects that call for adequate management and administration of these waters. Water is the most important resources of nature, most of the water is dewatered in mining operation for extraction of minerals, which arising the risk of water level of surrounded area. Water is mined out during the mining operation and most of water thrown out, that water should be utilizes proper ways by such as water treatment recycling operation which may increases the water level of those areas. Most of the world now a days facing out the problems of water so that to minimize this, we should make the proper ways of water treatment and recycling operations. This study provides an overview of the main problems derived from the mine-water relationship and also applicable technical solutions.

2. OBJECTIVES

To examine how water-related legal and regulatory risks can extend well beyond the operational phase of mining, highlighting that compliance during active operations may not be sufficient to mitigate liabilities, as post-closure obligations and environmental impacts on local water resources may persist for decades after mine closure.

2.1 Water and Mining

First of all, it should be emphasized that a successful mining operation depends largely on the adequate consideration of its interactions with water. Not taking this into account is suicidal. Therefore, technical and economic feasibility of a mine is often times dependent on the adequate knowledge of the hydrological background where the mine is situated and the subsequent projection of water-mining interactions, which will be more efficient and cost-effective the earlier it is started. This is why conscious mining firms make plans from the exploration to the post closure stages to use adequate tools to address potential water-related issues by designing and implementing adequate preventative and corrective measures.

At any rate, one must not forget that the water mining interaction is not limited to deposit exploration, but it also covers all ore milling processes, nor must we forget that one must take into account that once the mining operation has come to an end water-related impacts can linger for a long time. Because of this, technologies are now available to avoid or mitigate the adverse water effect in much diversified situations according to the nature of the deposit and type of mine involved. The results are dependent on the appropriateness of its design. To this end, one must be aware of the mining hydrogeological context, always bearing in mind that the activity must be dynamic, which requires updates and adjustments throughout the entire duration of the mining operation. At this point, it should be pointed out that, once the mines are developed, in much diversified hydro geological contexts, it is no easy task to realize and systematize water-mine relationships. To this end, the sole purpose of this is to approach a summary of this interaction, with a focus on the most frequent issues.

2.2 Drainage Water from Mines

Often times, a mine will provide much more water than ores. This is frequently the case of mines located under the piezometric level, and of unconfined or confined aquifers, out of which underground water must be pumped for as long as mining operation is ongoing resulting decreases of water level.

The main objectives of water study is related to mining operation to reserve the quantity of water so that increasing water level by method of water treatment and recycling operations.

Today's world-wide problems facing off due to decrease in quantity of water, so that retaining such situations we may emphasis on water treatment and recycling operations.

3. WATER AND WASTE

➤ From Mining

Other hydrological problems in mining activities can derive from piles of ore and mine spoils, dams and settling of fines and tailings, as well as liquid waste from the mine or ore processing plants.

➤ Solid Waste

Mining operations require the extraction of non-mineralized or low-grade sterile materials, generating tailings from its processing at quantities that are important to a greater or lesser degree. For example, in open pit iron mines, one often finds the sterile/ore ratio of 1 / 3 to 1 / 6 and, in the case of copper ores, minerals with yields of 0.5% are recovered, i.e. containing 99.5% of waste and tailings. These materials are accumulated in waste dumps and tailings dams or piles, and they can also be used as fillings for mining cavities. If all of this solid waste and the piles of ore they are not inert, they will become potential sources of water contamination, and its effect may last for a long time following completion of the mining operation. In this case, it is important to reduce water

inflow and infiltration as much as possible (from the rain or runoff). To do so, when the materials involved are reactive, they are appropriately placed on a continuous waterproof background, with a waterproof coverage (with surface drainage) and vegetable land for cultivation and restoration.

➤ **Liquid Effluents**

Many mining operations necessarily involve change to the natural water system. For example, if the operation is extended under the water level of an unconfined aquifer or intercept a confined aquifer, the underground water should be removed for as long as the mining activity continues, which will act as a “sink” in the aquifer system thanks to the piezometric drawdown caused by the drainage. Therefore, in many mines, the amount of water extracted is much larger than the amount of surface runoff. Depending on the lithological and mineralogical composition involved and the drainage method being used, these waters may be of excellent quality (especially if the so-called “preventive advanced drainage” technique is used) and discharged directly into the river system, or they may be used in irrigation and industrial applications. But when they have problems related to acidity, heavy metals, high salinity, etc. and the water falls short of minimum standards for release, it should be stored in evaporation dams or undergo appropriate treatment to achieve an acceptable quality for discharge. The quantity – and especially the quality – of wastewater generated by mining operations influence sore processing, age of the equipment and sizing of the process.

3.1 METHOD - WATER TREATMENT AND RECYCLING OPERATION METHODOLOGY

➤ **Recycled And Recirculated Water**

The most common sources are the reservoirs of tailings dams or those resulting from the process of dewatering by filtration, screening, and thickening. The correlation between the amount of fresh water and reused/recycled/recalculate water varies from case to case. The ideal situation is the so-called zero discharge, i.e., optimization of the recycling process makes it possible to reuse all of the water already used.

➤ **Water Use by The Mining Industry Methodology**

- I. Derivation or catchment of surface water or extraction of groundwater for end-user consumption or as an input to the production process;
- II. Discharge of effluents into water bodies.
- III. Other uses and interferences, such as:
 - Catchment of groundwater with a view to lowering water levels;
 - Diversion, correction and channeling of streams needed for mining research activities;
 - Damming for the settling and contention offices in water bodies;
 - Damming for the normalization of the water level or flow;
 - Systems for the disposal of spoils and waste;
 - Exploitation of minerals in water bodies, and
 - Catchment of water and discharge of effluents associated to the transportation of mining products.

3.1.1 Water Reuse by the Mining Industry

➤ **Recycled Water**

In the mining industry, recycled water is the water either returned to production after treatment or not and whose physical and chemical properties are suitable for the process. In operating plants that

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employ modern workflows, the recycling step includes water from thickeners, recovery systems, and tailings ponds, among others. Some mines, in addition to having adequate tailings ponds, are located close to the concentration plant, thus making the recycling process easier after proper settling.

In thickening operations, it is necessary to use coagulants and flocculants to increase the rate of sedimentation of solids, promote the clarification of water and reduce the size of thickeners. Thus, the physical and chemical properties of the water from the thickeners should be fit for use in the process. The pH and Eh values for the water are the simplest and most basic control parameters, yet this is not the only check.

Recycled water with chemical and physical properties consistent with the process is commonly obtained in modern plants in order to ensure control of the operation. Indeed, water recycling procedures vary widely depending on the type of ore involved. However, the following factors are generally taken into account:

- Limited availability of fresh water because of the location of the plant or due to environmental constraints;
- High water treatment costs to return it to the environment;
- Reduced operating costs from the recovery of residual reagents;
- Potential cost reduction for the pumping of fresh water from long distances;
- Removal of residual solids from the water, which is the most frequently used process in India;
- Compliance with legal requirements for the environment.

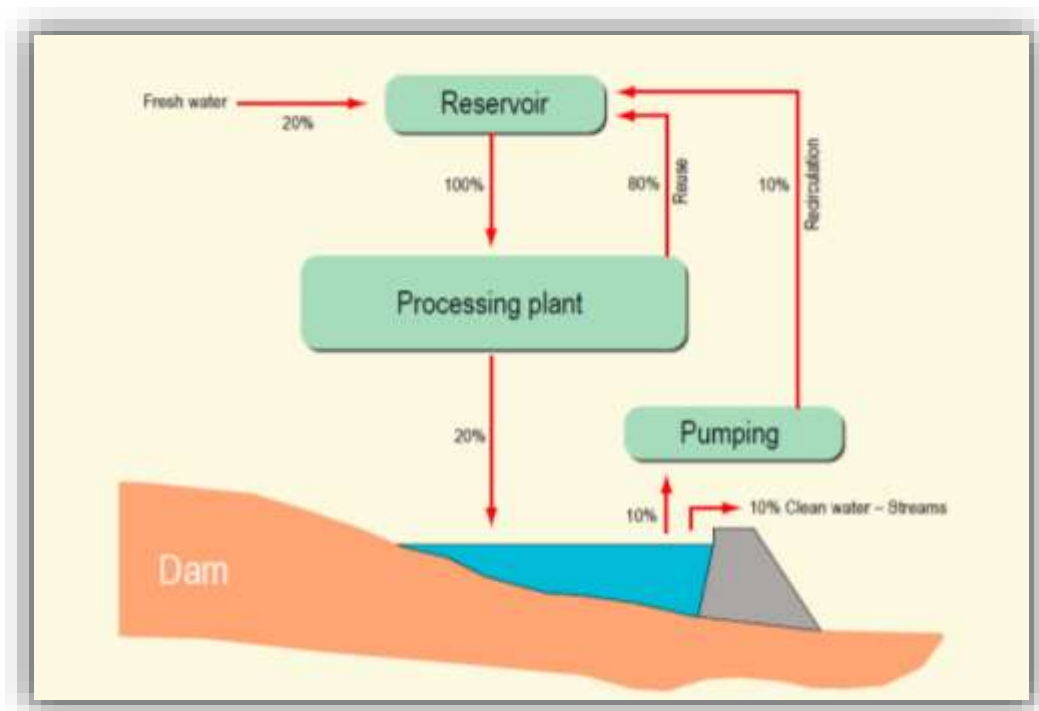


Figure 1 Schematic Representation of Water Recirculation System in Processing Plant

➤ Recycled Water Quality

Water recycling in mineral processing does not differ from water recycling in other applications, considering the characteristics of individual applications. Therefore, the results of previous studies in laboratory and pilot units determine water standards at the plant. Once the additional studies at industrial scale are completed, then the process optimization step is finished during the early years

of operation. Recycled water in an industrial plant has significant differences from the recycled watering the pilot plant. Reasons for this include the following:

- In commercial unit applications, it remains for a longer period in the thickeners than in studies at a pilot scale;
- The recycled water in industrial plants often comes from a tailings dam, whose environmental and chemical conditions have not been studied at a pilot scale;
- The fresh water used in the pilot plant is different from the one in the industrial plant, and therefore, the recycled water has physical and chemical properties that are equally distinct.

As a result, unexpected events occur in industrial operations, which require appropriate knowledge on the mineralogical constituents dissolved in water and how they interfere with the process. Therefore, monitoring of the recycled water and also the fresh water is recommended. Fresh or recycled water quality is defined according to operational requirements, the reagent system, and the definition of quality depends on the individual applications. The relevant water quality parameters are those that have a beneficial or harmful effect on the operation. This is why understanding these parameters is paramount, i.e., such parameters should be defined in detail. Sound knowledge of water chemistry and the elements contained in it is indispensable for treatment procedures of both the fresh and recycled water. Standardized analytical procedures are available for the determination of chemical parameters; however, these methods are continually tailored to specific situations and/or plant conditions. The chemical composition of water varies continuously throughout the duration of the operation, and requires an ongoing chemical analysis system to better monitor these variations. A database on the chemical composition of water should be put together during the pilot-scale studies, as well as at the beginning of the industrial operation. This procedure is valuable for adjusting and controlling the water supply system in every concentration plant while maintaining the operational stability of the process.

➤ Effluent Treatment Processes

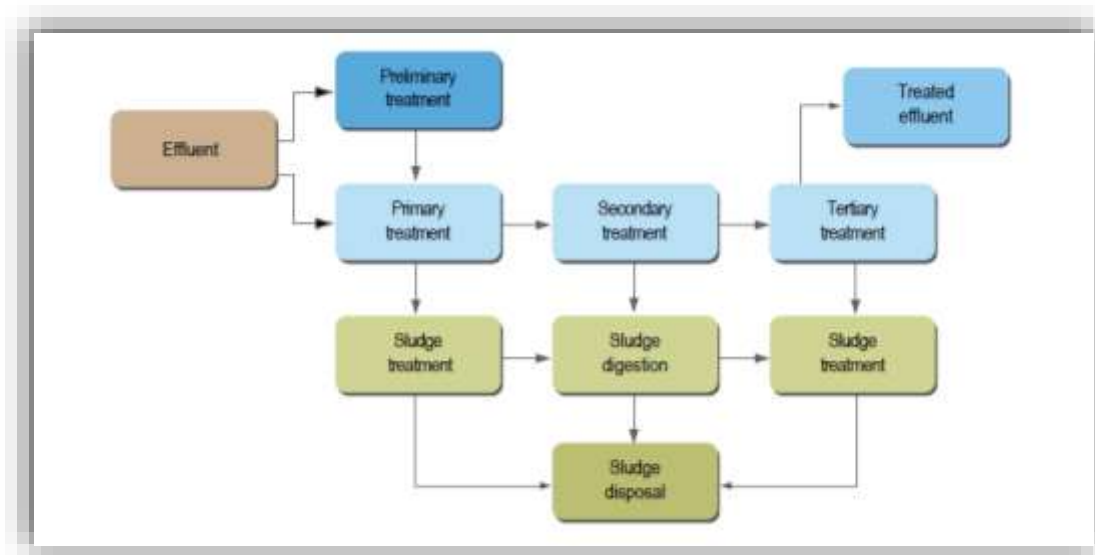


Figure 2 Flow Diagram of Effluent Treatment Process

Selection of an effluent treatment system generated by any human activity, including mining, depends on the following:

- The characteristics of the effluent, the predominant form of the pollutant, its biodegradability, presence of toxic organic and inorganic compounds;

- The required effluent quality after treatment (in accordance with the legislation in force);
- Operating cost of the process for the compliance with legal requirements.

Generally, each effluent treatment plant follows three steps, with different methods to define the overall process. The steps are: primary, secondary and tertiary (see Figure 17). Some authors add two more steps – a preliminary treatment before the primary step, for removal of constituents that interfere with the subsequent steps, and a step for treating the resulting solid residue, which is called sludge.

The primary treatment is used in most effluent treatment plants to remove dispersed solids, oils and fats. The separation of solids occurs in grids and through various processes such as disintegration, equalization, flocculation, sedimentation, and flotation. During the secondary or biological treatment step, metabolism of microorganisms is used to transform contaminants of effluents into harmless substances. In traditional effluent treatment plants, biological processes used to be restricted to the degradation of dissolved organic and colloidal compounds; oxidation of nitrogen from ammonia in nitrites and nitrates; conversion of nitrates into gaseous nitrogen; removal of phosphorus compounds; and stabilization of organic sludge. With biotechnological advancements, however, biological treatments are also applied to insoluble organic compounds and compounds that are harder to degrade, inorganic constituents and metallic ions. Tertiary treatments involve physical and chemical operations for removing specific types of pollutants, including microfiltration operations, adsorption (mostly with granular activated carbon), reverse osmosis, ion flotation, advanced oxidation, electro winning, etc.

4. RESULTS

The discussion on the use of water, its distribution, consumption, quality and preservation, etc., is not a specific aspect of the mining sector. This is a global issue that runs across the society. The wrongheaded notion that water is a renewable and abundant mineral has now been dispelled and the word “shortage” has been in the everyday life for its users for a while now. By 2025, only 25% of humanity will have water for their basic needs. This warning by the UN shows that water resources are one of its priority concerns. In view of this, there is vivid awareness in the mining industry of the need to use this mineral in a rational manner, imperfect balance with the environment and economic development; now this awareness needs to be shared by everyone.

The process engineers and/or researchers and specialists must have in-depth knowledge of the impacts of water and its constituents in the processes for which they are responsible. This will make it possible to establish wisely the parameters for quality control of the water to be used in mining activities, as well as that intended for disposal.

In the case of effluents from acid mine drainage, treatment promotes neutralization of acidity and precipitation as a consequence, and then immobilizing the species dissolved in the sludge. Alternatively, passive treatment systems can be used since they require little or no maintenance. These systems involve a large number of natural physical, chemical and biological processes resulting from interaction between water, soil, plants, microorganisms, and atmospheres to treat effluents from acid drainage, and bioremediation occurs.

5. CONCLUSIONS

Risk Assessment and Management of Water in Mining Industry by Method of Water Treatment and Recycling Operations avoids waste water in the environment and increasing the water level of the surrounded mine area which will automatically resolve the problems of waste water and utilizes the water for different uses not only for the mining industry but also for the entire society and people of those regions.

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