Innovations in Process Water Treatment for Enhanced Reuse in Alumina Refining

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Abstract

Alumina refineries are water-intensive, with significant water usage across multiple stages of the refining process. Consequently, water becomes an indispensable resource, driving a growing emphasis on sustainable water management practices essential for corporate responsibility and environmental stewardship. Hindalco is firmly committed to Environmental, Social, and Governance (ESG) principles, setting bold sustainability targets to drive progress.

Water scarcity presents a significant challenge for Hindalco Belagavi Plant, a 100 % specialty alumina and hydrate manufacturing facility located in a water-stressed region with no river water sources. The entire water supply for both the city and industrial operations is sourced from the Hidkal reservoir, which relies solely on monsoonal rains. In the specialty alumina and hydrate business, product quality is paramount, and the manufacturing process is highly complex, requiring precise control over various product grades. The use of high-quality water is crucial in this process, and any situation involving water scarcity or poor water quality can have a detrimental impact on the business.

To maintain a consistent, high-quality water supply for specialty alumina production and become water-reliant, the unit implemented the reuse of treated process effluent water as a key sustainability initiative. However, increasing the reuse of treated water led to significant issues, including high Total Suspended Solids (TSS), strong pungent odours, and a greenish tint, primarily due to caustic soda presence and algal growth. Traditional treatment approaches, such as acid neutralization and hypochlorite dosing, failed to resolve these challenges, instead exacerbating TDS levels and complicating operations. As a result, relying on treated process water became a challenge for sustaining plant operations. Moreover, the corporation has sharply reduced freshwater supply due to declining precipitation rates, a direct impact of climate change, intensifying water scarcity. To address this, an in-house study evaluated alternative treatment strategies through process innovation, including various flocculants, coagulants, and chemical aids. Trials initially did not yield desired results, necessitating process optimization through controlled dosage and treatment sequencing. This led to a breakthrough in eliminating colour and odour, while providing 100 % discontinuation of hypochlorite. The adoption of a coagulant-flocculant system significantly improved turbidity and clarity, enhancing treated water usability.

For the first time ever in the alumina industry, Hindalco Belagavi conducted detailed technical trials to improve treated process water quality, reducing freshwater intake and enabling sustained, self-reliant operations. These improvements offer a scalable, cost-effective approach to optimizing water treatment in specialty alumina refining, providing a replicable model for industries in water-scarce regions.

Keywords: ESG, Sustainability, Water reuse, Water-reliant, Innovation.

1. Introduction

Water is a critical resource in the industrial sector, playing an indispensable role in numerous production processes. In the context of alumina refineries, its importance is magnified due to its involvement in virtually every stage of the refining operation. Alumina, the key intermediate derived from bauxite ore through the Bayer process, is the foundational raw material for aluminium production. The Bayer process is inherently water-intensive, encompassing operations such as bauxite washing, digestion, clarification, precipitation, and calcination. Beyond these core processes, water is also essential for auxiliary operations, including cooling systems, dust suppression, and effluent management.

On the other hand, the increase in population and decrease in available water potential has a significant impact not only on water usage or withdrawal level, but also on security of the world. The reduction in the level of withdrawal means an increase in water scarcity, and this on the other round mean a rise in security tension. The other very related issue is deterioration of water in chemical quality after use [1]. Therefore, if the wastewater generated after withdrawal cannot be reused by implementing treatment techniques, it will go to the remaining water body through running ways and affect the chemical constituent of freshwater which again affect usage security [1]. The world is facing enormous challenges in meeting rising demands for clean water as the available supplies of freshwater are decreasing due to rapid population growth, urbanization, rapid industrialization, global climate change, and more stringent health-based water quality standards [2].

At Hindalco's Belagavi Plant, a 100 % specialty alumina and hydrate manufacturing facility, water assumes a particularly critical role. Located in a water-stressed region of Karnataka, the plant faces unique operational challenges due to its complete reliance on the Hidkal reservoir for water supply in absence of any river for water withdrawal. This reservoir, fed solely by monsoonal rains, also supports the city's municipal water needs, making efficient and sustainable water use a shared priority.

In the specialty alumina and hydrate business, where product quality and consistency are paramount, the need for high-purity water is even more pronounced. The manufacturing process is highly specialized, requiring tight control over a wide range of product grades to meet diverse end-use specifications. Any disruption in water availability or degradation in water quality poses a direct risk to operational continuity, product integrity, and overall business performance. To reduce freshwater consumption and enhance resource efficiency, the plant has implemented several conservation measures. One of the most impactful initiatives has been the recycling of treated process effluent for reuse in various process applications. This is facilitated through an on-site Effluent Treatment Plant (ETP), which treats the effluent to a quality suitable for internal reuse. Initially, this initiative resulted in substantial savings in freshwater usage and contributed significantly to the plant's sustainability goals.

However, over time, changes in climatic conditions began to impact the quality of the treated effluent. Seasonal variations and prolonged dry spells led to increased algal growth, greenish colouration, a pungent odour, and elevated levels of suspended solids in the recycled water. These changes rendered the treated water unsuitable for continued use in sensitive process operations, undermining the effectiveness of the recycling initiative and posing a significant risk to water conservation efforts. This paper presents a detailed analysis of the challenges faced in maintaining effluent water quality under changing environmental conditions and explores the advanced treatment strategies adopted by the Hindalco Belagavi Plant to restore and sustain the usability of recycled water in its critical manufacturing processes.

In summary, Hindalco continues to set a benchmark in sustainable industrial practices, with a strong focus on responsible and forward-looking water management. At the Belagavi unit, a circular water strategy built on the pillars of reuse, recovery, and innovation is actively driving the journey toward water positivity. A key highlight of this approach is the successful implementation of advanced chemical trials aimed at significantly improving the quality of treated effluent water. This proactive and science-driven initiative underscores Hindalco's commitment to expediting innovative solutions that support increased process reuse, reduce dependency on freshwater, and enhance overall operational resilience. By prioritizing such transformative actions, Hindalco positions itself as a leader in sustainability, water stewardship, and circular economy principles; reflecting its role as a socially responsible organization dedicated to safeguarding vital environmental resources for future generations.

7. References

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