

ST12 - Achieving Zero Liquid Discharge through Sustainable Water Management in Hindalco Renukoot

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Abstract

In recent years, the Global Aluminium Industry's top priorities shifted from competitive to competitive and sustainable. Water is one such resource which poses a critical sustainability challenge if not addressed properly. This paper presents a comprehensive analysis of sustainable water management and a unique approach implemented at the Hindalco Renukoot Integrated Alumina and Aluminium Complex, with a specific focus on achieving Zero Liquid Discharge (ZLD). Over the past five years, these efforts have resulted in a significant reduction in freshwater consumption by 34 % and a 50 % decrease in process effluent through sustainable means. The study begins by providing an overview of the complex's water-intensive operations and their associated environmental impacts. It emphasizes the complex's recognition of responsible water management as a crucial factor in mitigating these impacts and achieving long-term sustainability. The strategies employed to optimize water consumption are then discussed, including reengineering, design, customized solution development, design of experiments, advanced process technologies, water recycling and reuse systems, and the establishment of efficient water distribution networks. Additionally, the paper highlights the complex's integrated approach to water and process condensate management, specifically targeting ZLD. Hindalco's state-of-the-art treatment facilities, incorporating advanced technologies for sustainable water management, are showcased. The study addresses the challenges faced in meeting environmental standards while striving for ZLD, highlighting the importance of environmental conservation and water resource preservation. The findings presented in this paper demonstrate the positive impact of Hindalco's water management efforts, particularly in terms of reduced water consumption. The paper concludes with a discussion on the potential scalability and transferability of these strategies to other industrial complexes, emphasizing the need for knowledge sharing and collective action in achieving global water sustainability goals.

Keywords: Water management, Sustainable practices, Resource conservation, Water footprint, Zero Liquid Discharge.

1. Introduction

This paper presents a case study on Hindalco Industries Limited's Aluminium facility in Renukoot, which has experienced substantial growth since its establishment in 1962 with an initial capacity of 20 000 tpa of primary Aluminium metal. Through strategic expansions and effective asset management, the plant's production capacity has significantly increased to reach an impressive 420 000 metric tons per annum (MTPA). Operating across the entire aluminium value chain, Hindalco's facility in Renukoot encompasses alumina refining, aluminium smelting, and downstream rolling and extrusions. A critical aspect of the facility's operations is water sourcing and treatment [1], with the primary water source being the Renu River through a pumping station located downstream of the Rihand dam. Pre-treatment of the water takes place at the riverbank before it undergoes further purification at the on-site Water Treatment Plant. This involves various processes such as clarification using clarisettlers, disinfection with chlorine dioxide, and filtration through sand filters. After receiving its final treatment, the water is supplied to the different plants and the colony through gravity. This case study focuses on the achievement of Zero Liquid Discharge through sustainable water management practices implemented

at Hindalco's Aluminium complex at Renukoot. It explores the strategies and technologies employed to ensure efficient water utilization and the minimization of environmental impact.

2. Conceptual Approach

2.1. Engaging a Third Party for Baseline Water Study

To gain a comprehensive understanding of the complex's water usage, a third party is engaged to conduct a baseline water study. This study provided valuable insights into the current water consumption patterns, identified inefficiencies, and served as a basis for future improvement initiatives.

2.2. Formation of Water Task Force

A water task force is established, comprising members across all functions at the Renukoot complex. The task force's primary objective is to collaborate to achieve water conservation and reduce the effluent load. This cross-functional team brings together diverse expertise and perspectives to develop effective strategies.

2.3. Water Mapping and Water Balance Analysis

A detailed water mapping exercise is conducted to identify all water sources, consumption points, and the flow of water throughout the plant processes. This exercise helps create a comprehensive picture of water usage patterns. Subsequently, a water balance analysis is performed to quantify water inputs, consumption, losses, and outputs across different processes. This analysis serves as a basis for identifying potential areas for optimization and reduction in water consumption.

2.4. Quantitative Tap Survey

A quantitative tap survey is conducted to measure and record the water consumption at various points of use, such as washrooms, kitchens, and other utility areas at different elevations. This survey provides valuable data on the actual water consumption at each tap and helps identify areas where water-saving measures can be implemented.

2.5. Drain Survey and Daily Monitoring

A drain survey is carried out, and pinch points are established on drains for daily monitoring. This enables the identification of potential leakages, wastages, or unauthorized discharge of water. Regular monitoring allows for the timely detection of abnormalities and swift corrective actions.

2.6. Quantitative and Qualitative Analysis of Effluent Streams

Effluent streams from different processes are subjected to both quantitative and qualitative analysis. The quantitative analysis determines the volume of each effluent stream, while the qualitative analysis assesses the composition and characteristics of the effluents. This information helps identify opportunities for treatment, recycling, or reuse of effluent streams, leading to a reduction in the effluent load.

2.7. Brainstorming Sessions and Project Identification

The water task force conducts a series of brainstorming sessions to generate ideas and tests through lab-scale experiments for reducing river water consumption and effluent load. These sessions involve

members sharing their expertise and experiences to identify projects that can be implemented to achieve water conservation targets. The projects may include the installation of water-saving fixtures, process optimization, reuse of water, and implementation of water-efficient technologies.

3. Experiments Results and Discussion

To achieve Zero Liquid Discharge (ZLD) and reduce the dependence on fresh river water, several major initiatives based on Reduce, Reuse, Recycle and Replace principles, were undertaken at the complex. The following experiments were conducted to evaluate their impact on fresh river water saving and ZLD.

3.1. Modification in Condensate Handling System

The condensate handling system of the Alumina Plant was modified to segregate and utilize good condensate with conductivity (< 100 micro ohm m) as demineralized (DM) feed water to the boiler. This initiative resulted in a significant impact on fresh river water saving and ZLD, with a reduction of 2272 kiloliters per day (kL/day) (refer to Figure 1).

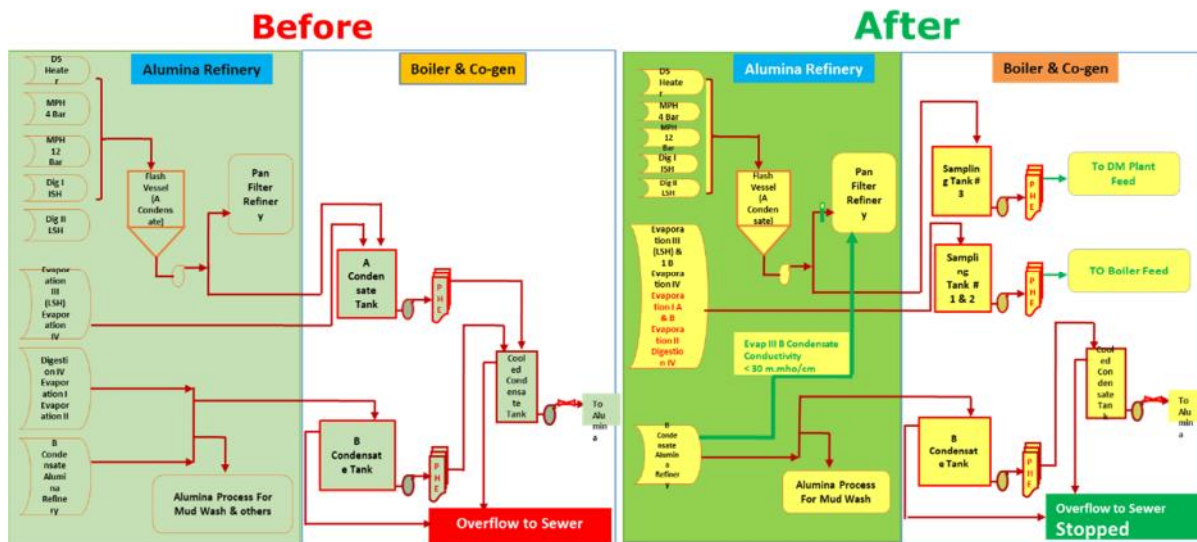


Figure 1. Modification in condensate handling system.

3.2. Reuse of Fresh Water in Hammel Mann Pump Operation

By arresting water flow from water storage tanks and carrying out engineering modification with solenoid valves at the Alumina Plant's Hammel Mann pumps, fresh water was effectively reused by a closed loop. This experiment led to a fresh river water saving of 200 kL/day and contributed to the overall ZLD efforts (refer to Figure 2).

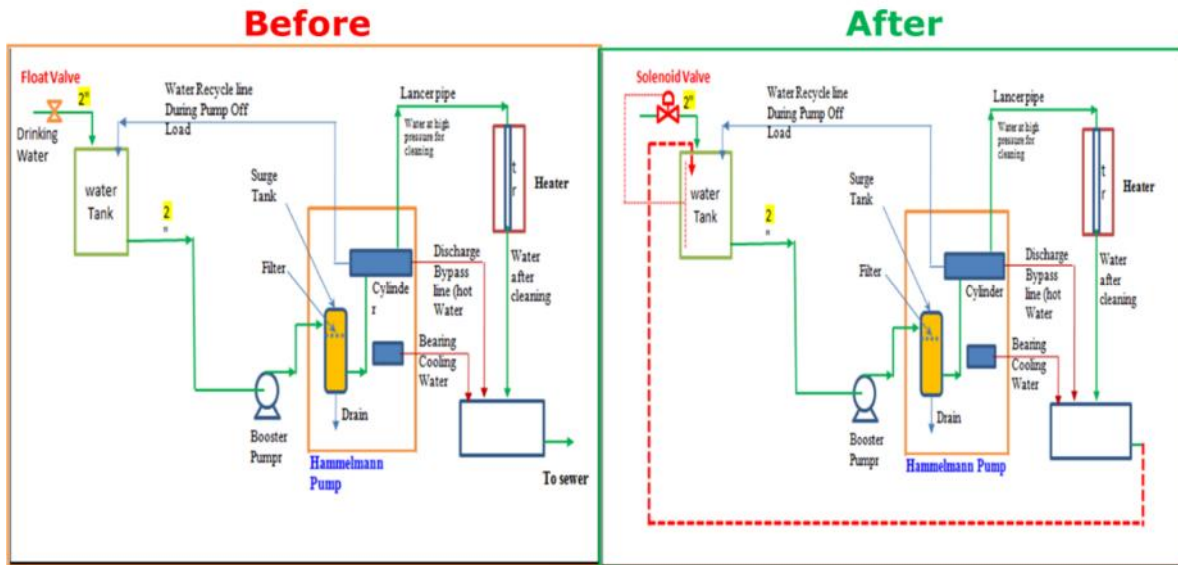


Figure 2. Reuse of fresh water in hammel mann pump Operation.

3.3. Reusing Vacuum Pumps Sealing Water and Purge Water

The sealing water and purging water from the vacuum pumps in the Alumina Plant were reused through the cooling process. This experiment resulted in a daily saving of 200 kL/day towards the ZLD objectives (refer to Figure 3).

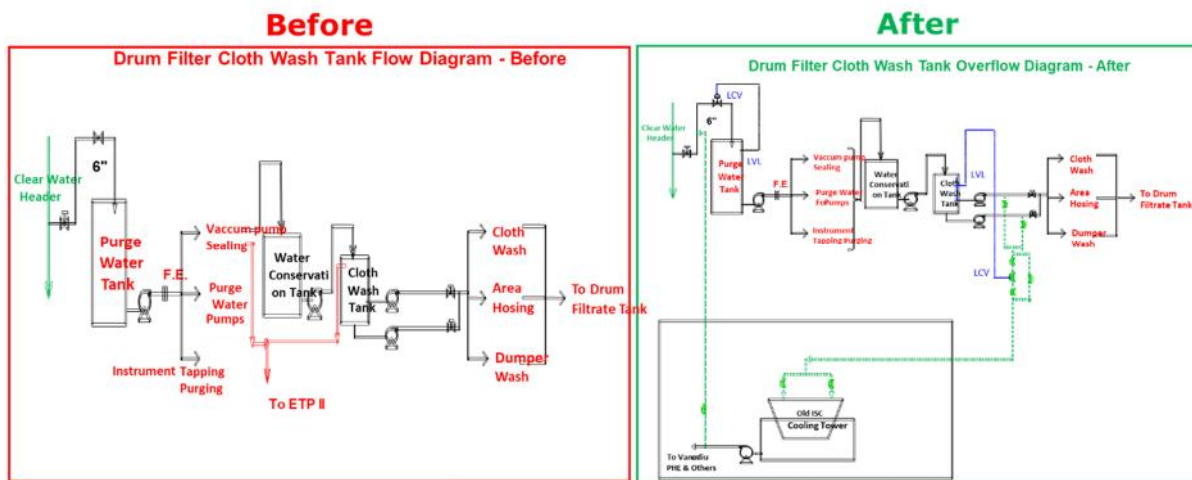


Figure 3. Reusing vacuum pumps sealing water and purge water.

3.4. Reusing Heater Cleaning Low pH effluent from Alumina Refinery

Infrastructure and pipeline layout were developed to enable the reuse of the entire heater cleaning acidic discharge with low pH influent ($\text{pH} < 2$) from the Alumina Plant to the Effluent Treatment Plant (ETP). The benefits included effluent reduction at the ETP inlet and a decrease in the consumption of fresh acid (refer to Figure 4).

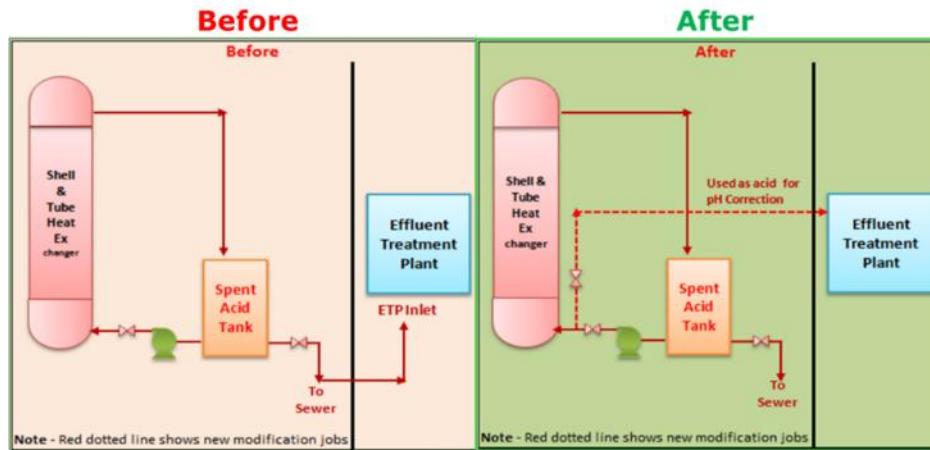


Figure 4. Reusing spent low Ph influent.

3.5. Recycling of Caustic Rich Stream

A surge facility with a capacity of 3000 kL was commissioned for the recycling of caustic-rich streams, which occurred during process leakages. This initiative required a capital expenditure of INR 14 800 000 (approx. 178 kUSD) and resulted in enhanced ETP availability through the reduction of shock load (refer to Figure 5).

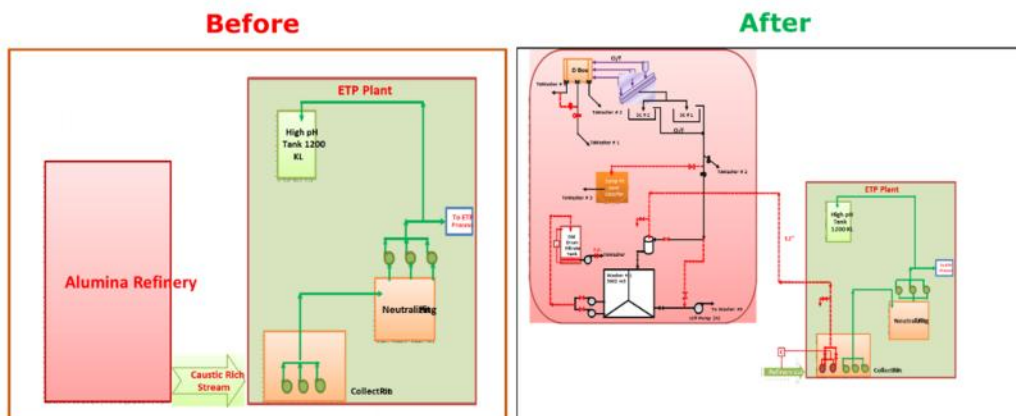


Figure 5. Recycling of caustic rich stream.

3.6. Reusing Conductivity Meter Cooling Water and Gland Seal Water

The cooling water from the conductivity meter and gland seal water was repurposed as DM feed water in the boiler. This experiment contributed to fresh river water saving of 102 kL/day and supported the ZLD objectives (refer to Figure 6).

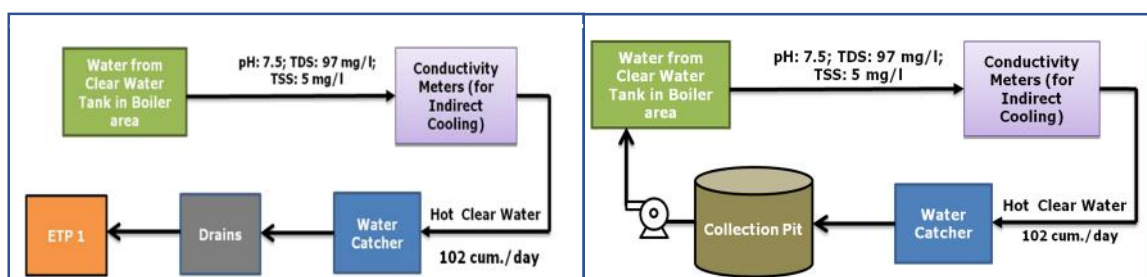


Figure 6. Reusing conductivity meter cooling water and gland seal water.

3.7. Partial Reusing of Backwash Water of DM Plant

Customized solutions were explored and developed to partially utilize the backwash water from the DM Plant ACF and MGF through segregation arrangements. This experiment resulted in a fresh river water saving of 587 kL/day and contributed to the ZLD efforts (refer to Figure 7).

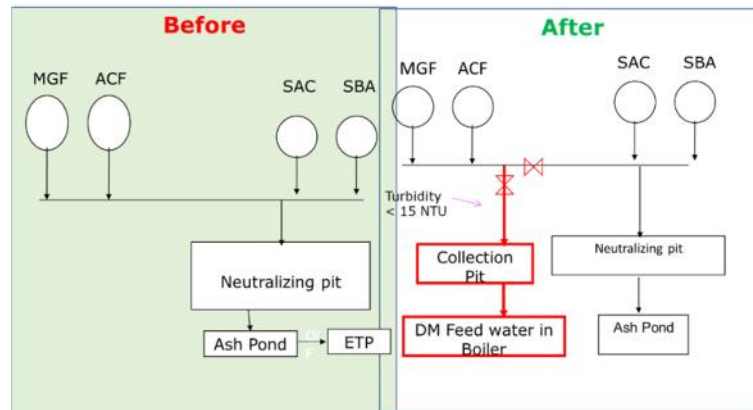


Figure 7. Partial utilization of backwash water.

3.8. Recycling of Cooling Water of Ball Mill Bearing

The cooling water of the ball mill bearing was diverted to the hot well of the compressor house CT, which was previously drained. This initiative had an impact of 90 kL/day on the ZLD objectives (refer to Figure 8).

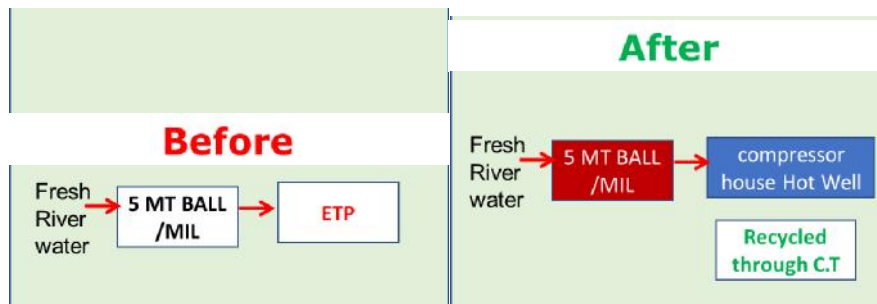


Figure 8. Diverting cooling water of ball mill bearing.

3.9. Cooling Water Optimization in Rodding Shop - Butt Press # 1 and 2 Power Pack

The closed cooling water circuit connected with the compressor cooling tower in the Rodding Shop was optimized. This experiment led to a fresh river water saving of 115 kL/day, thereby contributing to the ZLD goals (refer to Figure 9).

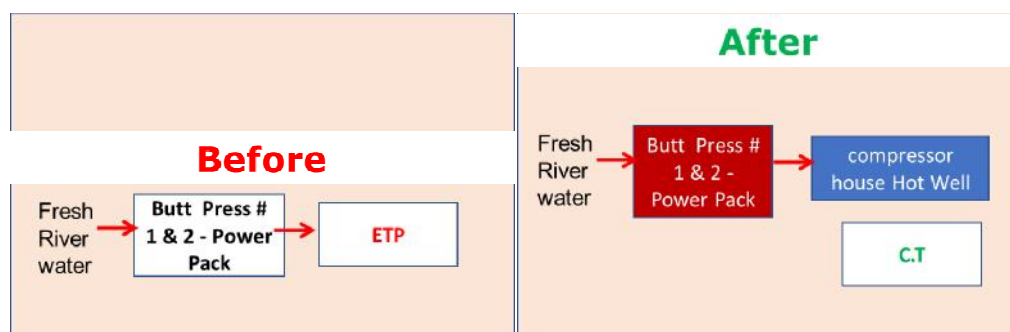


Figure 9. Cooling water optimization in rodding shop.

3.10. Additional Cooling Circuit in Induction Furnace Cooling Line

An additional cooling circuit was installed in the induction furnace cooling line to recirculate the water within the system instead of directing it to the ETP. This experiment resulted in a fresh river water saving of 102 kL/day and supported the ZLD efforts (refer to Figure 10).

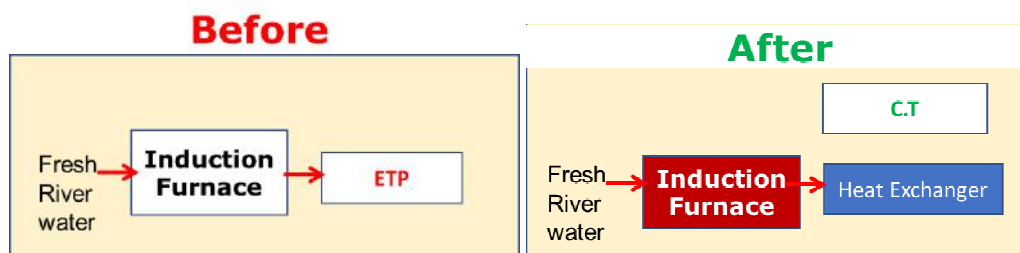


Figure 10. Additional cooling circuit in induction furnace cooling Line.

3.11. Water Pressure Optimization and Booster Pump Installation

Water pressure optimization was achieved by installing different sizes and designs of orifices in respective taps and local booster pumps in high-elevation areas. This initiative led to significant fresh river water saving of 900 kL/day, contributing to the ZLD objectives (refer to Figure 11).



Figure 11. Booster pump installation.

3.12. Replacement of BIB Cock with Push Cock

To further reduce the consumption of drinking water, BIB cocks were replaced with push cocks. This experiment resulted in a fresh river water saving of 100 kL/day and supported the ZLD goals (refer to Figure 12).



Figure 12. Replacement of BIB cock with push cock.

3.13. Recycling of ETP Treated Effluent for Flushing Purpose

Fresh water was replaced with ETP treated water in various areas, including urinal pots, cisterns (for flushing only), and cleaning toilet floors. This initiative led to fresh river water saving of 700 kL/day and contributed significantly to the ZLD efforts (refer to Figure 13).



Figure 13. Replacement of drinking water with ETP treated water.

3.14. Effluent Discharge Reduction through COC Optimization and Backwash Implementation

Several measures were implemented to reduce effluent discharge, including optimizing the Cycle of Concentration (COC) to 5 instead of 3, introducing chemical treatment improvements in cooling tower operation, and implementing a differential pressure (delta P) based backwash for side stream filters. These efforts resulted in a reduction of 600 kL/day towards ZLD, considering the operation of 32 cooling towers (refer to Figure 14).



Figure 14. COC optimization and backwash implementation.

3.15. Utilization of ETP Treated Water in Green Belt Development

ETP-treated water was utilized for the development of green belt areas and gardening. Approximately 141 hectares of land, accounting for around 29 % of the total plant area, were covered with greenery. ETP treated water contributed to this initiative, with a utilization rate of 2500 kL/day (refer to Figure 15).



Figure 15. Utilization of ETP treated water in green belt development.

3.16. ETP Treated Water for Dust Suppression

ETP-treated water was sprayed on the mud dumping road and coal yard area for dust suppression. This experiment resulted in a daily utilization of 700 kL/day of ETP-treated water (refer to Figure 16).



Figure 16. ETP treated water for dust suppression.

The above experiments and initiatives have collectively played a significant role in achieving Zero Liquid Discharge and reducing the dependence on fresh river water at the Alumina Plant.

4. Conclusion

In conclusion, the implementation of various initiatives aimed at reducing river water consumption and effluent load at the complex in Renukoot has yielded significant impacts. Firstly, the treated outfall from the plant premises has been reduced to zero since November 2021.

Furthermore, the initiatives have resulted in substantial savings in fresh river water. Initially, the daily reduction was 9530 kiloliters (kL), which accounted for a remarkable 53 % reduction in fresh river water consumption within the plant. However, with further improvements and additional initiatives, the savings have increased to 13 359 kL/day, resulting in a 35 % reduction in fresh river water consumption on an overall basis including plant as well as colony. These savings not only contribute to sustainable water management but also alleviate the strain on local water resources, promoting environmental stewardship.

The combined efforts of engaging a third party for baseline water study, forming a water task force, conducting water mapping and balance analysis, tap and drain surveys, qualitative and quantitative analysis of effluent streams, and brainstorming sessions have proven to be instrumental in achieving these impressive outcomes.

Moving forward, it is essential to continue monitoring and evaluating the implemented measures, identifying additional opportunities for improvement, and fostering a culture of water conservation within the complex. By maintaining a proactive and collaborative approach, the complex can further enhance its environmental performance and serve as a model for sustainable water management practices in industrial settings (refer to Figures 17-19).

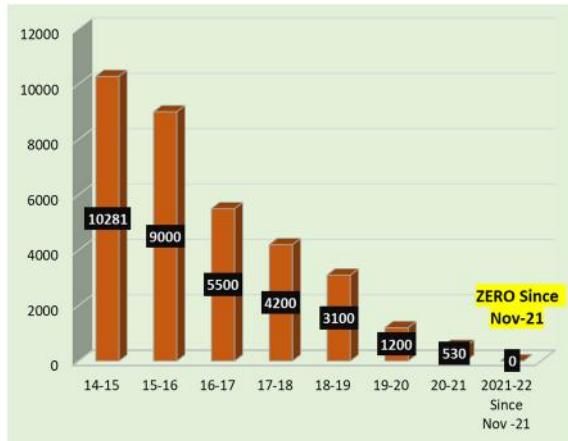


Figure 17. Effluent discharge in kL/day.

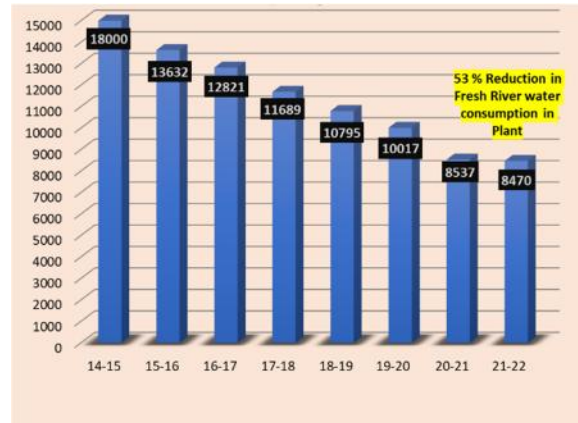


Figure 18. Reduction in freshwater cons. in plant

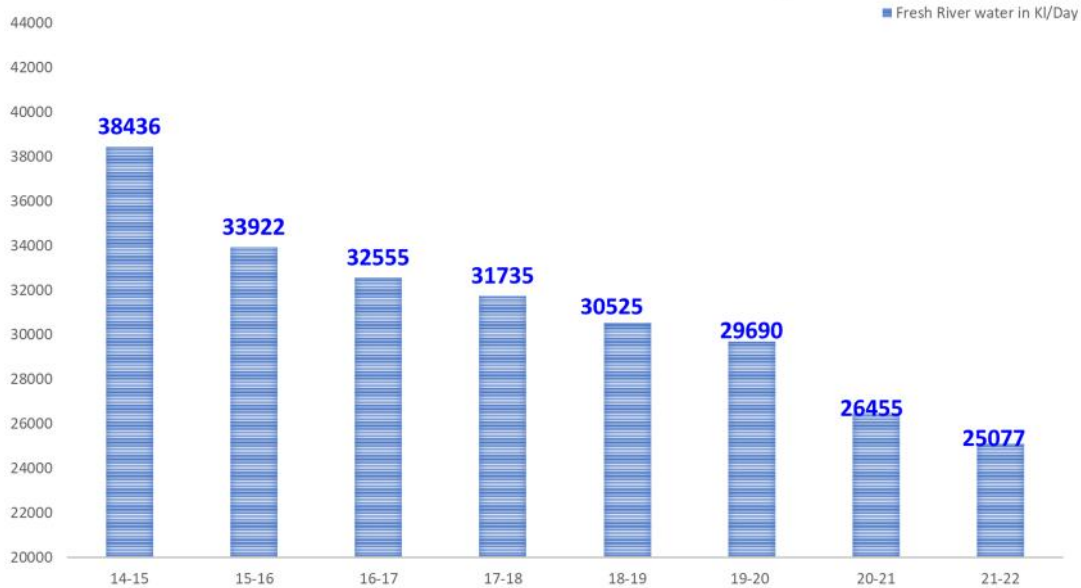


Figure 19. River water consumption in kL/day overall (plant and colony)

5. References

1. Metcalf & Eddy, Inc. et al., *Wastewater Engineering: Treatment and Resource Recovery*, McGraw-Hill, 2014.