Allied Blenders & Distillers

ABD/RANGAPUR/DISTILLERY/CPCB/2025-26/01
Date: 28.02.2026

To,
The Chairman,
Central Pollution Control Board,
Parivesh Bhawan, East Arjun Nagar,
Delhi - 110032

Subject: Submission of compliance status with reference to the directions issued by CPCB for M/s Allied Blenders and Distillers Limited (ABDL) for Existing Grain Based Distillery180 KLPD (180 KL x 365 days = 65,700 KLPA) with Existing 6.5 MW Power Plant at Survey No. 690/AA, 691/AA2, 692, Village - Rangapur, Mandal - Pebbair, District - Wanaparthy, State - Telangana, Pin Code – 509104 - Regarding.

Reference: B-505/IPC-III/Dist./2K18-19 Dated 17.09.2018.

Dear Sir,

With reference to the above, we are herewith submitting the current compliance status for the directions issued by CPCB and our compliance status is mentioned below.

Sr.No.	Directions	Compliance status
a)	It shall be ensured that the installed OCEMS devices are functionaing properly & continuously and that data from that device are uninterrutedly transferred to CPCB. Any failure in his regard shall be recitifed at the earlist.	Our OCEMS devices Installed and fuctioning properly and contniusouly the Equipmets are connected,the data is uninterrutedly transferred to the SPCB & CPCB servers.
b)	Unit shall ensure periodic calibration of the analyzers as per standard opearting procedure/recommendations of the suppier and submit the calibration results.	We are conducting periodic calibration of the analyzers as per the Standard Opearting Procedure.. AAQMS,EQMS &Stack Monitoring Equipments calibration Certifictes Enclosed as **Appendix - 1**
c)	The unit shall submit performance audit report of ETP system every year to CPCB from Govt. Expert institute.	We have conducted performance audit of our Effluent water treatment system (ZLD) through NGPRI and report is enclosed.as **Appendix - 2**

Thanking you.
For Allied Blenders and Distillers Limited,

Sudhansu Sekhar Rout
Head Distillery
Enclosure: As above
CC:

1. Regional Director – CPCB and MoEF&CC, Chennai.
2. Regional Office – TGPCB, Hyderabad
3. Member Secretary – TGPCB, Hyderabad

Performance Evaluation of ZLD System At Allied Blenders & Distillers Limited.
Sy.no-690/AA,691/AA2&692,
Rangapuram (V), Pebberu (M)
Wanaparthy District, Telangana State

For the year 2025-26

Prepared
By
Dr Bulusu Sreenivas

राष्ट्रीय भूभौतिकीय अनुसंधान संस्थान
NATIONAL GEOPHYSICAL RESEARCH INS
(COUNCIL OF SCIENTIFIC & INDUSTR... RESEARCH)
(वैज्ञानिक तथा औद्योगिक अनुसंधान)
Hyderabad 500007, INDIA

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Dr. Bulusu Sreenivas
Senior Principal Scientist
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Hyderabad 500007

27th January 2026

The methodology adopted for evaluation of waste water treatment system by Prof. A.V. Narasimha Swamy meets with the prescribed standards. The desirable parameters like pH, TSS, TDS, COD, VFA, BOD, SVI, MLSS, DO have been measured for this evaluation. The COD, removal efficiency of 99.1% and BOD removal efficiency of 98.0% exhibits optimal performance according to the report. The treated water utilization, for green belt development would be a good solution as per the performance evaluation report prepared by Dr. A.V. Narasimha Swamy (Retd. Professor, JNTU).

(Bulusu Sreenivas)

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Zero Liquid Discharge (ZLD) System Overview

The Zero Liquid Discharge (ZLD) system ensures the recycling of permeate (treated water) and converts solutes into solid residues, effectively minimizing liquid waste discharge into the environment. This approach aligns with sustainability goals and regulatory compliance. Below are the key details:

ZLD Definition

ZLD involves:

- Recycling industrial effluent by recovering permeate (treated water).
- Concentrating and thermally evaporating dissolved and suspended solids into solid residues for proper disposal.

ZLD Certification Parameters

Certification is based on two primary criteria:

1. Water Consumption vs. Reuse/Recycling: Evaluates the efficiency of treated wastewater recycling.
2. Solid Recovery: Measures the percentage of total dissolved and suspended solids recovered from the effluent.

Industrial Capacity and CFO Details

1. Manufacturing Capacity:
    - Production of rectified spirit, ethanol, or ENA: 180 KLD (Kiloliters per day).
    - Annual production capacity: 65,700 KLPA (Kiloliters per annum).
2. Consent for Operation (CFO):
    - CFO Number: 20234696127, issued on 19.10.2023.
    - Validity: Up to 31.03.2028.

Implementation Details

M/s Allied Blenders and Distillers Limited, located at Rangapur (V), Pebair (M), Wanaparthy District, Telangana State, has implemented the ZLD system in compliance with TGPCB norms and CPCB guidelines.

- Operation and Maintenance:
  The operation and maintenance of the ZLD system have been entrusted to M/s Thermax Engineering (Water & Wastewater Division).
- Performance Evaluation:
  The performance evaluation of the ZLD system has been conducted by:
  - Dr. B.B.S.V. Seshagiri Rao, EHS Consultant , Lead Auditor EMS,ESG, BRSR & Technical Expert, M/s TUV Nord India Limited.
  - Further examination was carried out by Prof.A.V.N. Swamy , Retired Head of The Department , Chemical Engineering, College of Engineering , JNTUA
  - Dr.B.Sreenivas is currently working as a Senior Scientist at the LAM-MC-ICPMS National Facility at NGRI-Hyderabad.

Significance

The ZLD system facilitates compliance with environmental regulations while supporting sustainable industrial practices by:

- Reducing water wastage.
- Mitigating the environmental impact of industrial effluents.

This commitment to environmental stewardship demonstrates the industry's dedication to sustainable and responsible manufacturing practices.

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INDEX

1.INTRODUCTION

Rapid industrial growth has significantly increased stress on freshwater resources and receiving water bodies. Distillery industries, in particular, generate high-strength wastewater characterized by elevated BOD, COD, TDS, color, and organic load. In view of the environmental sensitivity of such effluents, **the** Central Pollution Control Board (CPCB) **has** mandated **Zero Liquid Discharge (ZLD)** for distillery units.

Zero Liquid Discharge is a wastewater management strategy in which **100% of wastewater generated is treated, recycled, and reused**, and **no liquid effluent is discharged outside the plant premises**. Dissolved and suspended solids are recovered as solid residues for safe disposal or beneficial reuse.

M/s Allied Blenders & Distillers Limited has implemented a comprehensive ZLD system incorporating **biological, physico-chemical, membrane, and thermal treatment technologies** to comply with regulatory requirements and promote sustainable water management.

This report presents a **detailed performance evaluation** of the ZLD system based on field observations, sampling, laboratory analysis, and mass balance during December 2025.

2. Acknowledgements

This report presents a detailed performance evaluation of the ZLD system based on field observations, sampling, laboratory analysis, and mass balance studies conducted during our site visit on 10th December to 12th December 2025.

The evaluation was conducted by Prof. (Retd) AVN Swamy, Department of Chemical Engineering, JNTUA, under my guidance the study was carried out following a site visit. The visit was accompanied by Dr. B.B.S.V. Seshagiri Rao, Technical Consultant appointed by M/s Allied Blenders & Distillers. On-site activities and technical demonstrations were expertly provided by

- Umasankar Padhi, Regional Head
- Sudhansu Sekhar Rout, Process Head
- Vaddipalli Srinivasarao, Environmental Engineer

of M/s Allied Blenders & Distillers Limited, who also provided all necessary technical inputs. Our sincere thanks are extended to the management and staff of M/s Allied Blenders & Distillers Limited for their full cooperation and support during this evaluation.

3.OBJECTIVES OF THE STUDY

The objectives of the present study are:

1. To evaluate the overall performance of the ZLD system.
2. To assess wastewater treatment efficiency at each unit operation.
3. To verify compliance with CPCB and TGPCB ZLD norms.
4. To assess water recovery, reuse efficiency, and pollution load reduction.
5. To evaluate operational stability of biological, membrane, and thermal systems.
6. To recommend improvements, if any, for optimized system performance

4.0 Industry Profile

M/s Allied Blenders & Distillers Limited (ABDL) is a well-established and reputed distillery unit engaged in the manufacture of Rectified Spirit (RS), Extra Neutral Alcohol (ENA), and Ethanol. The unit forms part of one of India's leading alcoholic beverage manufacturing groups, with a strong focus on quality production, regulatory compliance, and sustainable environmental management.

The distillery unit is located at Rangapuram Village, Pebberu Mandal, Wanaparthy District, Telangana State, in an industrially designated area with appropriate infrastructure support. The location has been selected considering environmental safeguards, availability of utilities, and compliance with statutory siting guidelines prescribed by regulatory authorities.

The manufacturing facility operates with a licensed production capacity of 180 KLD, corresponding to an annual production capacity of 65,700 KLPA of alcohol products. The production process involves fermentation, distillation, evaporation, and by-product recovery, which inherently generates high-strength wastewater, particularly in the form of spent wash.

Recognizing the environmental sensitivity of distillery effluents, the unit has implemented a comprehensive Zero Liquid Discharge (ZLD) system, incorporating advanced treatment technologies such as Decanter, Multiple Effect Evaporator (MEE), anaerobic and aerobic biological treatment, tertiary filtration, ultra-filtration, and two-stage reverse osmosis systems. The ZLD system ensures that no liquid effluent is discharged outside the factory premises under normal operating conditions.

The facility has also adopted water conservation and resource recovery measures, including maximum reuse of treated wastewater within the process and cooling systems, and recovery of solids in the form of Dried Distillers Grains with Solubles (DDGS), which is utilized as a valuable by-product for cattle feed. These initiatives reflect the company's commitment to sustainable manufacturing practices and circular economy principles.

The plant is equipped with modern process controls, online monitoring instruments, and trained operational personnel to ensure continuous compliance with environmental standards. Operation and maintenance of the wastewater treatment and ZLD facilities are carried out as per standard operating procedures and manufacturer recommendations.

5.0 Regulatory Status – Consent for Operation (CFO)

M/s Allied Blenders & Distillers Limited is operating under a valid Consent for Operation (CFO) issued by the Telangana State Pollution Control Board (TGPCB) in accordance with the provisions of the Water (Prevention and Control of Pollution) Act, 1974 and the Air (Prevention and Control of Pollution) Act, 1981.

The details of the CFO are as follows:

- CFO Number: 20234696127
- Issuing Authority: Telangana State Pollution Control Board (TGPCB)
- Date of Issue: 19 October 2023
- Validity Period: Up to 31 March 2028

The Consent for Operation stipulates specific conditions related to:

- Maximum production capacity
- Freshwater consumption and wastewater generation
- Implementation and operation of the ZLD system
- Treatment, reuse, and disposal of effluents and solid wastes
- Monitoring and reporting of environmental parameters

The distillery unit is operating within the permitted production capacity and water consumption limits as prescribed in the CFO. All wastewater streams are treated and reused in accordance with the approved ZLD scheme, and no treated or untreated effluent is discharged outside the premises.

Regular monitoring, record-keeping, and submission of compliance reports are being carried out as per TGPCB requirements. During the present performance evaluation study, the plant was observed to be fully compliant with the CFO conditions, and the environmental management systems were found to be adequate and effective

6.0WATER CONSUMPTION & WASTEWATER GENERATION AS PER CFO

Table NO-1

Purpose	Fresh Water (KLD)	Recycled Water (KLD)
Process	525	900
Cooling Tower Make-up	608	951
Boiler Feed	400	–
Green Belt / Ash Quenching	–	155
CO_2 Plant	12	–
Domestic	15	–
ETP / WTP	840	–
Total	2400	2006

Wastewater Generation Table.NO-2

Source	Quantity (KLD)	Treatment System
Process (Spent Wash)	900	Decanter + MEE
Cooling Tower Blowdown	179	ETP → UF → RO
Boiler Blowdown	40	ETP
CO_2 Plant	12	ETP
Domestic	12	ETP
Fermentation Washings	90	Recycled

7. ZLD TREATMENT SYSTEM

The Zero Liquid Discharge (ZLD) treatment system is a critical environmental management component for distillery units, designed to ensure that all wastewater generated during the manufacturing process is completely treated, recovered, and reused, with no liquid effluent discharged outside the plant premises. Considering the high organic load and dissolved solids typically present in distillery effluents, the ZLD system adopts a multi-stage and integrated treatment approach to achieve stringent regulatory compliance and sustainable water management.

System Concept and Regulatory Framework

The ZLD system implemented in distillery operations is designed in accordance with the guidelines prescribed by the Central Pollution Control Board (CPCB), which mandate zero discharge of effluents and emphasize maximum water recovery, minimization of freshwater consumption, and effective management of treatment residues. Compliance with these guidelines is essential to ensure environmentally responsible operation and protection of surrounding ecosystems, including green belt areas.

Treatment Process Description

The ZLD treatment system generally comprises the following major stages:

A)Primary Treatment

Primary treatment involves screening, equalization, and physico-chemical processes to remove coarse solids, grit, oil & grease, and to stabilize fluctuations in flow and pollutant load. Neutralization is carried out using suitable chemicals to adjust the pH to optimal levels for downstream biological treatment.

B) Secondary (Biological) Treatment

Secondary treatment is designed to reduce organic load (BOD and COD) through biological processes. In distillery units, this typically includes:

- Anaerobic treatment systems (such as UASB reactors) for high-strength wastewater, which facilitate the breakdown of complex organic matter and generate biogas as a valuable by-product.
- Aerobic treatment systems (such as activated sludge process) to further oxidize residual organics and improve effluent quality.

The biological treatment units are operated under controlled conditions to ensure process stability, effective pollutant removal, and consistent performance.

C) Tertiary and Advanced Treatment

Following biological treatment, the clarified effluent is subjected to tertiary treatment and advanced purification processes, which include:

- Pressure Sand Filters (PSF) and Activated Carbon Filters (ACF) for removal of suspended solids, color, and residual organics
- Ultra-Filtration (UF) to remove fine particulates and colloidal matter
- Reverse Osmosis (RO) systems to remove dissolved salts and achieve high-quality permeate suitable for reuse

The RO system is generally configured in multiple stages to maximize water recovery and minimize reject generation.

D)Thermal Treatment and Evaporation

High-TDS streams such as RO reject and spent wash are treated through Multiple Effect Evaporators (MEE) and decanter systems. These units concentrate dissolved solids, allowing:

- Recovery of condensate water for reuse
- Conversion of dissolved and suspended solids into solid residues, such as DDGS

This ensures complete elimination of liquid waste discharge.

Water Reuse and Resource Recovery

Treated water recovered through the ZLD system is recycled and reused within the plant, including applications such as:

- Process water
- Cooling tower make-up
- Boiler feed (after appropriate polishing)
- Green belt development and ash quenching

In addition to water recovery, the ZLD system facilitates resource recovery, including:

- Biogas generation from anaerobic digestion, which can be utilized as an energy source
- Recovery of nutrients from sludge, which can be safely used for agricultural or soil conditioning purposes, subject to regulatory approval

Environmental and Sustainability Benefits

Implementation of the ZLD system provides multiple environmental and sustainability benefits, including:

- Complete elimination of liquid effluent discharge
- Significant reduction in freshwater consumption
- Protection of surface water and groundwater resources
- Controlled management of solid residues and sludge
- Support for green belt development within the plant premises

The ZLD approach aligns with sustainable industrial practices, circular economy principles, and environmental stewardship, enabling distillery units to operate responsibly while meeting regulatory and social expectations.

Process Wastewater Treatment System

(Grain Stillage / Spent Wash + RO-II Rejects – Decanter & MEE)

The process wastewater generated from the distillery mainly consists of grain stillage (spent wash), which is characterized by high organic load, elevated Total Dissolved Solids (TDS), colour, and suspended solids. In addition, high-TDS RO-II reject generated from the membrane treatment system is also routed to the process wastewater treatment stream to ensure complete Zero Liquid Discharge (ZLD).

To effectively manage these high-strength effluents, the plant has implemented a dedicated thermal and mechanical treatment system comprising Decanter and Multiple Effect Evaporator (MEE).

Decanter System

The combined stream of grain spent wash and RO-II reject is first fed to a high-speed decanter. The decanter separates the incoming slurry into two distinct fractions:

- Wet Cake – rich in suspended solids and organic matter
- Thin Slop – liquid fraction containing dissolved solids

The decanter plays a critical role in reducing the solids load on downstream evaporation units, improving thermal efficiency, and facilitating effective solids recovery.

Multiple Effect Evaporator (MEE)

The thin slop from the decanter is fed to the Multiple Effect Evaporator (MEE), where it undergoes multi-stage evaporation under controlled temperature and pressure conditions. In the MEE:

- Water is evaporated and recovered as condensate
- Dissolved solids are concentrated to higher solids content

The use of multiple effects significantly reduces steam consumption and improves energy efficiency. The MEE ensures maximum recovery of water and complete elimination of liquid effluent. Condensate Recovery and Reuse

The condensate water recovered from the MEE is of suitable quality and is recycled back into the distillery process as make-up water, thereby:

- Reducing fresh water consumption
- Supporting sustainable water management practices. Condensate quality is regularly monitored to ensure its suitability for reuse.

Wet Cake Handling and Utilization

The wet cake separated in the decanter, along with concentrated solids from the evaporation process (if applicable), is handled as a valuable by-product. The wet cake is:

- Dewatered to the required moisture content
- Safely transported and utilized as cattle feed in accordance with applicable guidelines

This practice supports resource recovery and waste minimization, aligning with circular economy principles.

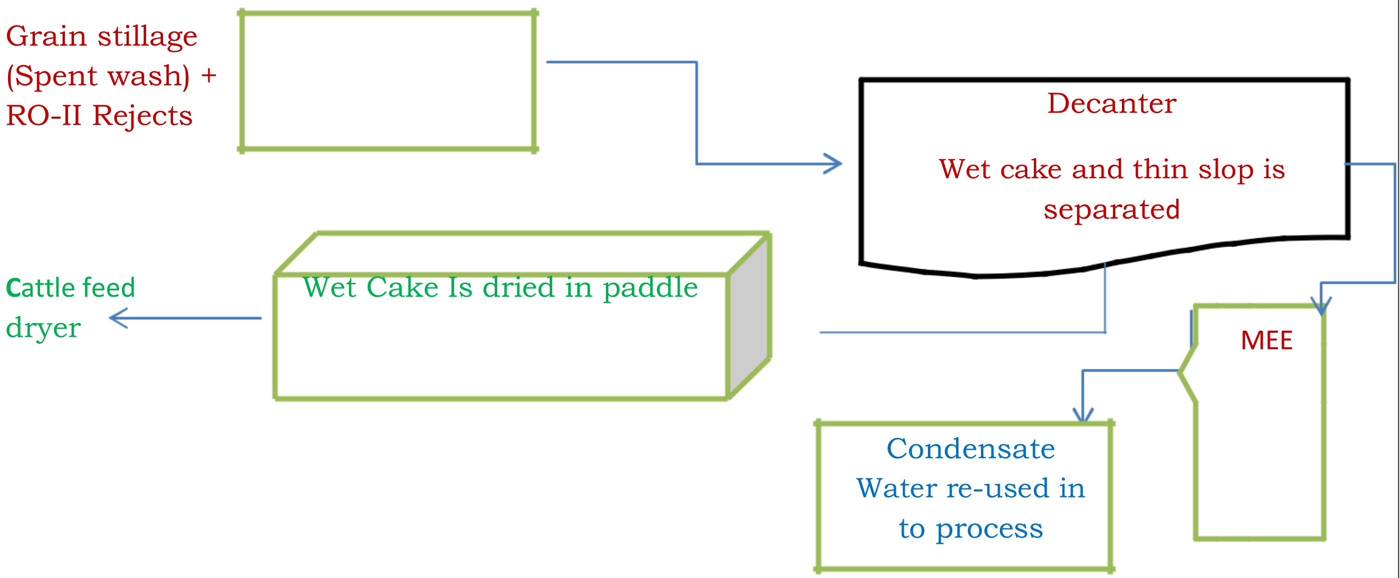
Overall ZLD Compliance

The integrated decanter–MEE system ensures that:

- Spent wash and RO-II rejects are fully treated
- No liquid effluent is discharged outside the premises
- Water is maximally recovered and reused
- Solid residues are converted into useful by-products

Thus, the process wastewater treatment system forms a critical component of the Zero Liquid Discharge framework, ensuring environmental compliance and sustainable operation of the distillery unit

Process waste water treatment system



DECANTER AND DECANTER FEED PUMP

Biological treatment of wastewater in distillery ZLD systems inevitably results in the generation of excess biological sludge due to the growth and multiplication of microorganisms during the degradation of organic matter. Effective handling and disposal of this excess biomass is a critical component of the overall wastewater treatment and ZLD system.

The sludge management system adopted at the plant follows a systematic five-step approach, comprising sludge withdrawal, storage, conditioning, dewatering, and final disposal, ensuring safe handling and compliance with environmental regulations.

Sludge Withdrawal and Storage

Excess sludge is periodically withdrawn (bled) from the biological treatment system through the sludge recirculation pipeline using a controlled branch connection. The withdrawn sludge is in the form of a thick slurry with high moisture content.

The sludge is conveyed to a sludge holding tank, which is provided with a suitable aeration arrangement. Aeration is maintained to prevent anaerobic conditions, avoid putrefaction, and control odour generation. The holding tank also serves as a buffer to ensure uniform feed to the dewatering system.

Sludge Conditioning

Prior to dewatering, the sludge undergoes conditioning to enhance solid–liquid separation. Suitable polymers or coagulant aids are dosed into the sludge stream to improve floc formation and increase dewatering efficiency. Proper conditioning reduces the moisture content of the sludge cake and improves the overall performance of the decanter.

Decanter Feed Pump

A dedicated Decanter Feed Pump is installed to transfer conditioned sludge from the sludge holding tank to the decanter unit. The pump is designed to handle high-density sludge with adequate pressure and flow control to ensure:

- Uniform and continuous feed to the decanter
- Prevention of hydraulic shock
- Stable and efficient dewatering operation

The feed pump plays a crucial role in maintaining consistent decanter performance and preventing mechanical stress on the equipment.

Sludge Dewatering in Decanter

The Decanter is employed as the primary sludge dewatering unit. It is one of the most commonly used and reliable systems for dewatering biological sludge in industrial wastewater treatment plants. The decanter separates the sludge into:

- Dewatered sludge cake with significantly reduced moisture content
- Separated liquid (filtrate/centrate), which is routed back to the treatment system for further processing

The dewatered sludge cake is collected and handled as per approved solid waste management practices, while the filtrate is recycled within the ZLD system.

Final Disposal and Environmental Compliance

The dewatered sludge, converted into a semi-dry or dry sludge cake, is stored temporarily in a designated area and disposed of or utilized in accordance with CPCB/TGPCB guidelines. This controlled sludge management system minimizes environmental impact, reduces volume for disposal, and supports sustainable waste handling practices.

UNIT DESCRIPTIONS – EFFLUENT TREATMENT PLANT (ETP)

Bar Screen Chamber

The Bar Screen Chamber is the first unit of the Effluent Treatment Plant and serves as a preliminary treatment unit. Its primary function is to prevent the entry of large floating and suspended solids such as plastic cups, paper dishes, polythene bags, rags, and other debris into downstream treatment units.

The screening is achieved by installing a set of vertical metal bars across the effluent flow path. The spacing between the bars generally ranges from 10 mm to 25 mm, depending on design requirements. In most ETPs, two-stage screening is provided:

- Coarse Bar Screen – with wider spacing to remove larger debris
- Fine Bar Screen – with smaller spacing to remove finer solids

Effective screening is essential to prevent clogging and damage of pumps, pipelines, and mechanical equipment, and to avoid plant shutdowns. Regular manual or mechanical cleaning of screens is necessary, as unattended screens can lead to odour generation, backing up of effluent in upstream pipelines, and operational disturbances.

Collection cum Equalization Tank

Effluent from the bar screen chamber is conveyed to the Collection cum Equalization Tank, which acts as the first major collection and buffering unit in the ETP.

The primary function of the equalization tank is to equalize fluctuations in flow rate and pollutant concentration arising from variable industrial operations. It ensures a uniform and continuous flow to downstream treatment units, thereby preventing shock loading on biological and chemical processes.

The tank is designed with adequate capacity to handle peak inflow conditions. Generally, an equalization tank capacity equivalent to 4–6 hours of average hourly effluent flow is considered sufficient. Mixing or aeration may be provided to prevent solids settling and septic conditions.

Effluent Lift Pumps

Effluent Lift Pumps are installed to transfer wastewater from the equalization tank to the anoxic or coagulation units at a controlled and uniform rate. Typically, pumps are provided in working and standby configuration to ensure uninterrupted operation.

The pumping rate is calibrated to deliver a constant flow, thereby protecting downstream treatment units from hydraulic fluctuations. These pumps play a critical role in maintaining process stability across the ETP.

Coagulation and Flocculation Tank

The Coagulation and Flocculation Tanks form part of the physico-chemical treatment stage and are generally provided prior to sedimentation and filtration.

- Coagulation involves rapid mixing of chemicals to neutralize the electrical charges of suspended particles, resulting in the formation of micro-flocs.
- Flocculation involves gentle agitation that allows micro-flocs to aggregate into larger, heavier flocs that can be easily settled or filtered.

This process significantly enhances the removal of suspended solids, turbidity, colour, and colloidal matter, thereby improving the efficiency of downstream biological and membrane treatment units.

Chemical Dosing for Coagulation and Flocculation

Chemical dosing systems are provided for accurate and controlled addition of treatment chemicals, such as:

- Lime and Soda Ash – for pH correction and hardness removal
- Alum – as a primary coagulant due to its high efficiency in turbidity and colour removal
- Polymers / Poly-Aluminium Chloride (PAC) – as flocculants to promote aggregation of fine particles

These chemicals facilitate effective solid–liquid separation, improve water clarity, and enhance sludge dewatering characteristics. Proper dosing ensures optimal treatment efficiency with minimal chemical wastage.

UASB Reactor

The Up-flow Anaerobic Sludge Blanket (UASB) Reactor is a key biological treatment unit designed to treat high-strength organic wastewater under anaerobic conditions.

In this system, wastewater flows upward through a dense blanket of granular anaerobic sludge. Organic matter is degraded by anaerobic microorganisms, converting it into biogas (methane and carbon dioxide). The upward flow and gravitational settling maintain the sludge blanket in suspension.

Over time, microorganisms form dense, compact granules, which provide a large surface area for biological activity and result in high treatment efficiency. The UASB reactor significantly reduces BOD and COD while producing useful biogas.

Lamella Tube Settler

The Lamella Tube Settler is installed after coagulation and flocculation to enhance solid–liquid separation.

Inclined tube settlers increase the effective settling area, allowing fine flocs and agglomerated particles to settle rapidly under gravity. The settler performs three main functions:

- Settling and thickening of biomass and suspended solids
- Production of a clear supernatant
- Collection of settled sludge for recirculation or further treatment

The thickened sludge is transferred for further processing, while clarified water flows to the biological treatment units.

Extended Aeration Tanks

The Extended Aeration Tank is the heart of the aerobic biological treatment process. In this unit, wastewater is mixed with a high concentration of microorganisms, collectively referred to as Mixed Liquor Suspended Solids (MLSS).

Continuous aeration supplies dissolved oxygen required for microbial metabolism, enabling the breakdown of residual organic matter. The process maintains a long sludge age, resulting in stable operation and reduced sludge generation.

Secondary Clarifier

The Secondary Clarifier allows gravity settling of biological solids from the mixed liquor exiting the aeration tank.

Its functions include:

- Settling of biomass solids
- Thickening of settled sludge
- Production of clear supernatant water

Settled sludge is partially recycled back to the aeration tank to maintain the desired microbial concentration, while excess sludge is withdrawn for dewatering.

Sludge Transfer Pump

Sludge Transfer Pumps are used to recirculate settled sludge from the secondary clarifier to the aeration tank and to bleed excess sludge from the system.

Maintaining the proper sludge age (25–30 days) and MLSS concentration is essential for effective treatment. Controlled sludge recirculation and withdrawal ensure system stability and optimal biological performance.

Activated Carbon Filter (ACF)

The Activated Carbon Filter is a tertiary treatment unit installed after the Pressure Sand Filter. It removes:

- Residual BOD and COD
- Colour and odour
- Trace organic compounds

The ACF significantly improves the aesthetic and chemical quality of treated water, making it suitable for membrane treatment.

UF Feed Pump

The UF Feed Pump transfers treated water from the UF feed tank to the Ultra Filtration (UF) membrane system at the required operating pressure.

The UF system operates in filtration and backwash cycles. As contaminants accumulate on the membrane surface, pressure increases, triggering an automatic backwash to restore permeability.

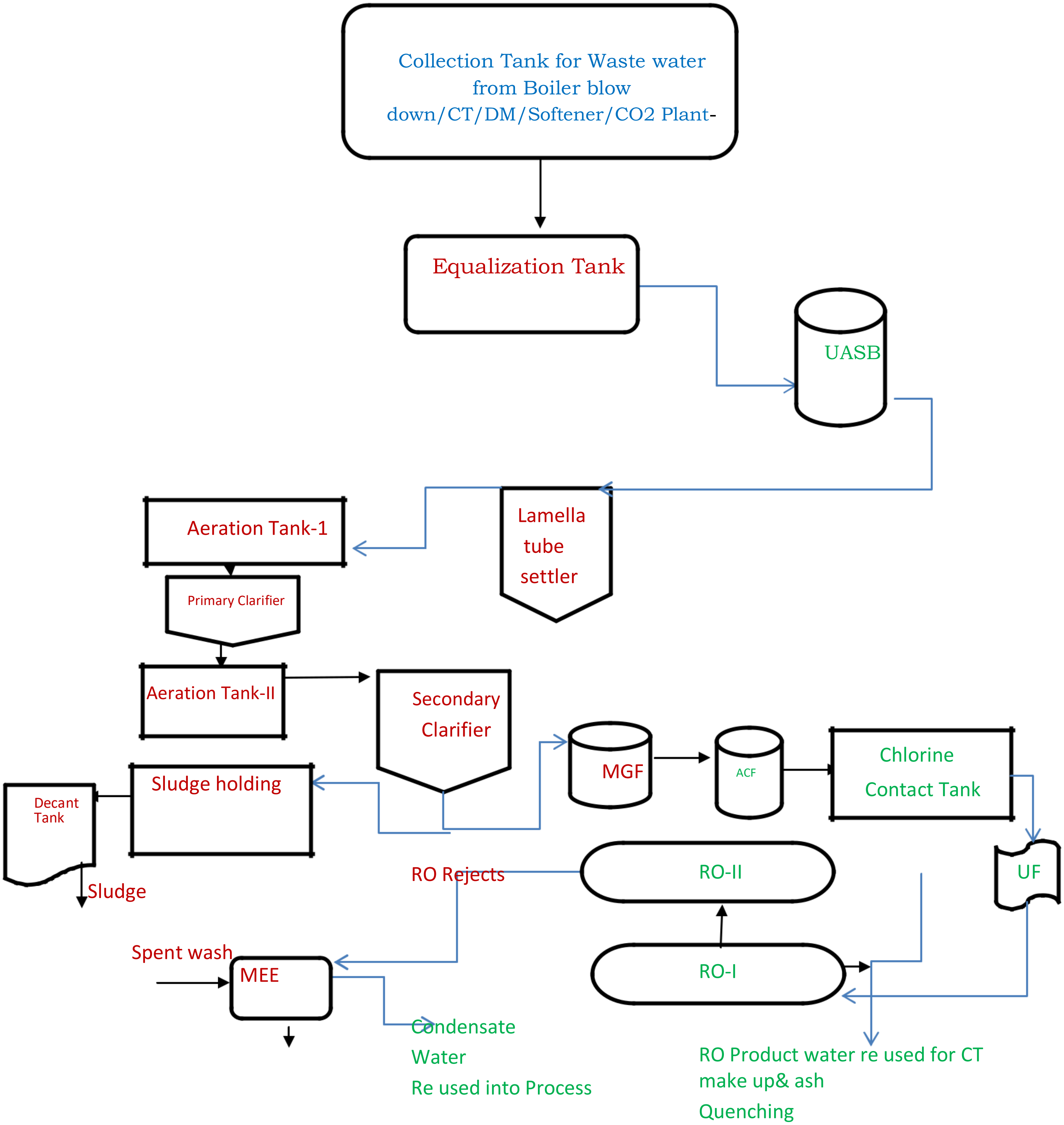
Ultra Filtration (UF) Membrane Module

Ultra Filtration (UF) is a pressure-driven membrane process used to remove suspended solids, colloids, bacteria, and macromolecules. UF membranes typically reject particles larger than 0.03 microns.

UF systems are highly automated, require minimal operator intervention, and have membrane life spans of 3–5 years or more. Modules are available in tubular, hollow-fiber, spiral wound, and plate-and-frame configurations.

The UF permeate serves as feed water to the two-stage Reverse Osmosis (RO) system, while the RO permeate is reused as cooling tower make-up water, supporting the Zero Liquid Discharge objective.

ZLD system



Collection Tank for Waste water from Boiler blow down/CT/DM/Softener/CO2 Plant-
Equalization Tank
UASB
Lamella tube settler
Aeration Tank-1
Primary Clarifier
Aeration Tank-II
Secondary Clarifier
MGF
ACF
Chlorine Contact Tank
Decant Tank
Sludge holding
Sludge
UF
RO-II
RO-I
RO Rejects
Spent wash
MEE
Condensate Water Re used into Process
RO Product water re used for CT make up& ash Quenching

ZLD Performance Study

The present study was conducted from 10th to 12th December 2025 to evaluate the performance of the Zero Liquid Discharge (ZLD) system at M/s Allied Blenders & Distillers, located at Sy. No. 690/AA, 691/AA2 & 692, Rangapuram Village, Pebberu Mandal, Wanaparthy District.

Wastewater samples were analyzed for key water quality parameters, including pH, Total Suspended Solids (TSS), Total Dissolved Solids (TDS), Chemical Oxygen Demand (COD), Volatile Fatty Acids (VFA), Biochemical Oxygen Demand (BOD), Sludge Volume Index (SVI), Mixed Liquor Suspended Solids (MLSS), and Dissolved Oxygen (DO).

Samples were collected from 11 different locations within the treatment system. For each location, 2 to 3 liters of wastewater were collected in clean polyethylene containers. A total of 11 grab samples were collected during each shift and combined to form a composite sample for analysis.

The sampling points included

1. Collection Tank
2. Equalization cum Neutralization Tank
3. UASB Inlet and Outlet
4. Clarifier
5. Aeration Tank – I
6. Aeration Tank – II
7. Secondary Clarifier
8. After Sand Filter and Activated Carbon Filter
9. RO–I Feed Water
10. RO–I Permeate and Reject Water
11. RO–II Permeate and Reject Water

Generalized wastewater parameters were evaluated to assess the overall performance and efficiency of the distillery effluent treatment plant (ETP) and its compliance with ZLD requirements.

Analytical Methods Adopted for Distillery Industry Wastewater Analysis

(Table No. 03)

S.No	Parameter	Method Used	Equipment/Experiment Used
1	pH	Electrometric	Digital pH meter
2	BOD_5 @ 20°C	Dilution Method	Volumetric glassware, BOD bottles, Incubator
3	COD	Open Reflux	COD apparatus, Round Bottom Flask
4	Total Solids	Gravimetric Method	Gooch crucible, Centrifuge, Electronic Balance, Burner
5	Total Dissolved Solids	Gravimetric Method	Gooch crucible, Centrifuge, Electronic Balance, Burner
6	Suspended Solids	Gravimetric Method	Gooch crucible, Centrifuge, Electronic Balance, Burner

A).Feed Water Parameters

Table No. 04 – Average Water Quality (mg/L unless otherwise mentioned)

S.No	Parameter	Boiler Blow Down	Cooling Tower Blow Down	DM Water Softener Regeneration	CO_2 Plant Waste Water	Combined Average
1	pH	9.5	6.8	6.0	6.5	6.38
2	TSS	70	350	50	1600	300.33
3	TDS	1500	800	5500	850	2239.33
4	COD	50	80	500	6000	5420.0
5	BOD	25	80	50	6250	806.0
6	Chlorides	45	120	1800	40	796.03
7	Hardness (Mg)	48	35	2350	28	998.33
8	Hardness ($CaCO_3$)	55	24	2150	12	912.53

B).Average Wastewater Generation During Study Period Table.NO-05

Source	Quantity (KLD)
Boiler Blow Down	40.0
Cooling Tower Blow Down	82.24
Domestic Wastewater	10.0
CO_2 Plant Waste Water	12.0
Total	144.24

C). Process Water Generation & Treatment

- Feed to Treatment:
  - Spent Wash from Process: 578 KLD
  - RO-II Reject Water: 15.62 KLD
  - Total Effluent: 593.62 KLD
- Treatment Process:

1. Multiple Effect Evaporator (MEE):
   - Concentrates total effluent from 593.62 KLD.
   - Solids content increased to 30%.
2. Decanter Operation:
   - Further concentrates MEE output to 90% solids.
   - Condensate recovery: 526 KLD of water is recycled into the process.

- By-Product Generation:
  - Concentrated solid residue is processed into DDGS (Dried Distillers Grains with Soluble).
  - Average DDGS Production: 70 TPD (Tones Per Day)

D).Observations:

- Water Recovery Efficiency:
  - Approximately 88.7% of effluent (526 KLD out of 593.62 KLD) is recovered as process water.
  - Demonstrates high-efficiency MEE-condensate recycling.
- Solid Concentration Efficiency:
  - Sequential concentration from 30% → 90% maximizes DDGS yield.
- Sustainability & Resource Optimization:
  - Condensate recovery reduces freshwater consumption.
  - DDGS production provides a marketable by-product, supporting Zero Liquid Discharge (ZLD) objectives.

E). Recommendations for Technical Optimization

1. Regularly monitor TDS, BOD, COD of MEE condensate to ensure suitability for reuse in the process.
2. Conduct periodic maintenance of MEE and Decanter to prevent fouling and scaling.
3. Evaluate energy consumption of MEE and explore heat integration to reduce operational costs.
4. Ensure proper storage and handling of DDGS to maintain quality for feed or industrial applications.

Table NO-06

Parameter	Value
Total effluent (Spent wash + RO Reject)	593.62 KLD
Solids after MEE	30%
Solids after Decanter	90%
Condensate recovered	526 KLD
Recovered water reuse	88.7%
Average DDGS production	70 TPD

1.Waste water Collected into Collection tank cum Equalization Tank (Table.No-07)

pH Adjustment Monitoring

S.No	Date of Collection	pH Before Hydrate	pH of Equalization Tank	Lime Consumption (Kgs/Day)	pH After Adjustment
1	10.12.2025	5.96	5.68	40.0	7.07
2	11.12.2025	6.00	5.84	30.0	7.04
3	12.12.2025	6.10	5.91	55.0	7.04

Effluent Characteristics – Pre- and Post-UASB Treatment

Pre-UASB Influent Parameters. Table .NO-08

Date of Collection	Date of Analysis	Flow Rate (KL/hr)	pH (Before Adjustment)	pH (After Adjustment)	TSS (mg/L)	TDS (mg/L)	COD (mg/L)	BOD (mg/L)
10.12.2025	10.12.2025	–	5.9	7.07	500	1928	2952	980
11.12.2025	11.12.2025	–	5.96	7.04	484	2068	3280	990
12.12.2025	12.12.2025	–	6.0	7.0	1796	2080	970	502

Observations:

- The influent pH ranged between 5.9 and 6.0 before adjustment and increased to ~7.0 after lime dosing.
- TSS and COD show fluctuations due to variations in feed composition.
- BOD values are significant, indicating the requirement for biological treatment.

2. UASB Outlet Parameters Table .NO-09

Date of Collection	Date of Analysis	Flow Rate (KL/hr)	pH (Before Adjustment)	pH (After UASB)	VFA (mg/L)	TSS (mg/L)	TDS (mg/L)	COD (mg/L)	BOD (mg/L)
10.12.2025	10.12.2025	25	5.84	7.18	80	256	1846	460	208
11.12.2025	11.12.2025	–	5.90	7.20	80	240	1960	212	410
12.12.2025	12.12.2025	–	5.95	7.17	80	248.3	1726	210	480

Observations:

- UASB treatment effectively reduced COD and BOD significantly, showing high organic load removal efficiency.
- pH of the UASB outlet increased slightly due to buffering, remaining in the neutral range (~7.17).
- Volatile Fatty Acids (VFA) remained stable at ~80 mg/L, indicating controlled anaerobic digestion.
- TSS decreased markedly after UASB treatment, supporting sedimentation efficiency before further treatment.

Audit Observations

Based on the wastewater generation, treatment, and monitoring data during the study period, the following technical observations are made:

1. The total average wastewater generation (excluding spent wash) is 144.24 KLD, comprising boiler blowdown, cooling tower blowdown, domestic wastewater, and wastewater from the CO_2 plant.
2. The spent wash generation is 578 KLD and RO reject is 18 KLD, totaling 596 KLD, which is entirely treated through a Multiple Effect Evaporator (MEE) followed by a Decanter, confirming compliance with Zero Liquid Discharge (ZLD) requirements.
3. The MEE system effectively concentrates spent wash solids up to 30%, and subsequent decanting increases solids concentration to 90%, resulting in an average DDGS generation of 70 TPD.
4. The MEE condensate generation of 526 KLD is completely reused in the process, significantly reducing fresh water consumption and ensuring no liquid effluent discharge outside the premises.
5. All non-spent wash wastewater streams are routed to the collection tank cum equalization tank, ensuring proper hydraulic and organic load balancing prior to treatment.
6. pH correction using hydrated lime is found to be effective, with pH values consistently adjusted from acidic levels (5.68–5.91) to a neutral range of 7.04–7.07, which is suitable for downstream treatment and system protection.
7. The hydrated lime consumption (30–55 kg/day) is within normal operating limits and reflects stable influent characteristics during the monitoring period.
8. No abnormal fluctuations in wastewater flow or quality were observed during the study period, indicating stable and continuous plant operation.
9. Overall, the wastewater management system, including segregation, treatment, reuse, and monitoring practices, is technically adequate, environmentally compliant, and operationally efficient during the study period.

10.Collection Tank cum Equalization Tank

- Wastewater pH before adjustment was acidic, ranging from 5.68 to 5.91, indicating the need for neutralization prior to biological treatment.
- Hydrated lime consumption varied between 30–55 kg/day, depending on influent characteristics.
- After lime dosing, the pH was consistently maintained between 7.04 and 7.07, which is optimal for UASB performance.
- Flow equalization appears adequate, ensuring uniform loading to the UASB reactor.
- pH control system is effective and stable during the monitoring period.

Observation:
The equalization and pH correction system is functioning satisfactorily and provides favorable conditions for anaerobic biological treatment.

11.UASB inlet

Inlet pH remained neutral due to proper lime dosing, Organic load (COD/BOD) is **high**, making UASB technology appropriate., Consistent influent characteristics indicate stable upstream operations.
UASB Outlet

- Outlet pH is stable and slightly alkaline, confirming healthy anaerobic activity.
- VFA levels are within acceptable limits, indicating **no process upset**.
- Significant reduction in organic matter is observed.
- Sludge washout is minimal and within expected limits.

12.The UASB reactor is operating in a **stable and efficient manner**, with good biomass activity and no signs of inhibition.

Pollution Load Reduction (Indicative)

BOD reduction of ~55% confirms effective anaerobic degradation.
COD reduction of ~39% is consistent with primary biological treatment and indicates scope for further polishing (e.g., aerobic treatment).
TSS reduction of ~53% reflects good solids retention in the reactor.

3.TSS Reduction After Tube Settler (Table No. 10)

Source	Date of Sample	TSS (mg/L)
Inlet	10.12.2025	256
Outlet	10.12.2025	78.5
Inlet	11.12.2025	240
Outlet	11.12.2025	75.2
Inlet	12.12.2025	248.3
Outlet	12.12.2025	68.6

Technical Observations

1. Consistent Influent Quality
    - Inlet TSS ranges narrowly between 240–256 mg/L, indicating stable feed conditions.
2. Stable Outlet Performance
    - Outlet TSS remains consistently below 80 mg/L, demonstrating reliable solids removal.
3. Good Removal Efficiency
    - Average TSS removal is approximately 70%, which is technically sound for conventional sedimentation/clarification processes.
4. Slight Performance Improvement on 12.12.2025
    - Highest removal efficiency observed (~72.4%) suggests optimal settling or favorable operating conditions on that day.
5. Operational Implications
    - No abnormal fluctuations observed; the tube settler system appears hydraulically and operationally stable.
    - Continued monitoring of flow rates, sludge withdrawal, and potential inlet shock loads is recommended to maintain or improve performance.

4. Aeration Tank -1Table.NO.11

Source	pH	TSS	TDS	COD	BOD	DO	SVI	MLSS	MLVSS
10.12.2025(int)	7.18	64	1846	208	460	1.6	-	-	-
10.12.2025(out)	7.62	32	1809	72.8	52	1.5	210	2250	1800
11.12.2025(int)	7.2	60	1960	212	410	1.7	-	-	-
11.12.2025(out)	7.7	26	1899	58.3	53	1.65	240	2500	1990
12.12.2025(int)	7.17	66	1726	210	480	2	-	-	-
12.12.2025 (out)	7.64	37	1680	58.8	46	1.92	300	2680	2144

Technical Observations: 1.pH remains within the desirable range (6.5–8.5) for biological treatment and discharge standards.

Suspended Solids (TSS), Inlet: 60–66 mg/L- Outlet: 26–37 mg/L, Consistent reduction in TSS indicates effective clarification and settling. Slight increase on 12.12.2025 (37 mg/L) may be linked to Higher SVI (300 mL/g), Possible sludge bulking or poorer settleability.

2.DO levels are low for an aeration tank (ideal: 2–3 mg/L)
3.SVI increasing trend (210 → 300 mL/g) indicates, Deteriorating sludge settleability, Early-stage sludge bulking
MLVSS/MLSS ratio (~0.8) indicates healthy and active biomass
4. Excellent BOD removal (88.81%) confirms effective biological oxidation.
COD removal (~69.85%) is satisfactory for conventional ASP.
Moderate TSS removal @49.98% with scope for improvement by controlling sludge settleability.
Negligible TDS removal@ 2.60% which is process-limited and expected.
4. Increase aeration to maintain DO ≥ 2.0 mg/L
Monitor F/M ratio and sludge age (SRT)
Consider selective sludge wasting to control SVI

5. Aeration Tank-II. Table.NO.12

Source	pH	TSS	TDS	COD	BOD	DO	SVI	MLSS	MLVSS
10.12.2025(int)	7.62	32	1809	71.8	52	1.5	210	2250	1800
10.12.2025(out)	7.98	17	1752	32.31	22.88	1.6	300	3150	2120
11.12.2025(int)	7.7	26	1809	58.3	53	1.6	240	2500	1990
11.12.2025(out)	7.89	14	1784	25.77	23.05	1.6	310	3000	2240
12.12.2025(int)	7.64	37	1680	58.8	46	1.92	300	2680	2144
12.12.2025 (out)	7.94	18	1624	25.57	20.60	1.5	280	2890	2160

Technical Observations

1.Influent pH ranged 7.62–7.70; effluent 7.89–7.98. Effluent pH is slightly higher but well within acceptable biological treatment range. Indicates stable biological activity and buffering during treatment.

2. MLSS increased from 2250–2680 mg/L (int) to 2890–3150 mg/L (out). MLVSS increased from 1800–2144 mg/L to 2120–2240 mg/L. Indicates healthy biomass concentration and good sludge age.

3. Organic Load Removal

The treatment system demonstrates effective biological oxidation, with average COD reduction of 55.71 % and BOD reduction of 56.42 %. The close correlation between COD and BOD removal indicates stable microbial activity and good process control.

4.Suspended Solids Removal

TSS reduction of 48.42 % reflects satisfactory performance of the secondary clarification process. Consistent reduction confirms adequate sludge settling, though optimization may further improve solids capture.

5.Dissolved Solids Behavior

TDS reduction of only 2.60 % is minimal, which is expected since conventional biological treatment processes are not designed for dissolved salts removal. No adverse impact on process performance is observed due to TDS.

6. Sludge is being produced continuously, as indicated by increasing MLSS/MLVSS in the outlet. High SVI (200–310 mL/g) suggests bulky, poorly settling sludge, meaning sludge occupies more volume in the clarifier. Sludge age / wasting schedule may need adjustment to prevent accumulation in the system. Sludge disposal planning should consider MLVSS content (~70% of MLSS) for proper handling and potential dewatering.

6.After Secondary Clarifier. Table.NO-13

Date	Source	pH	TSS	TDS	COD	BOD
10.12.2025	Inlet	7.98	17	1752	32.31	22.68
10.12.2025	Out let	8.01	10	1702	28.3	20.50
11.12.2025	Inlet	7.89	14	1784	25.77	23.05
11.12.2025	Out let	7.96	08	1744	23.65	21.50
12.12.2025	Inlet	7.94	18	1624	25.57	20.06
12.12.2025	Out let	8	10	1521	22.50	19.50

TSS removal (42.9%) → directly forms sludge.
COD (11%) & BOD (6.5%) reduction → part of it is converted into microbial biomass, which becomes sludge.
TDS (3.7%) → mostly remains in solution, minimal contribution to sludge.

7.After MGF filtration. Table.NO-14

Date	Source	pH	TSS	TDS	COD	BOD
10.12.2025	Inlet	8.01	14	1702	28.3	20.50
10.12.2025	Out let	8.2	10	1698	27.55	20.0
11.12.2025	Inlet	7.96	11	1744	23.65	21.50
11.12.2025	Out let	8.17	10	1735	22.25	21.00
12.12.2025	Inlet	8.0	15	1521	22.50	19.06
12.12.2025	Out let	8.11	12	1510	22.00	19.00

Technical Observations – MGF Filtration

1. pH: Slight increase after filtration (≈8.0–8.2), normal due to aeration and media effect.
2. TSS Removal (≈20%): MGF effectively polishes the water, removing fine suspended solids not settled in the secondary clarifier.
3. TDS Reduction (≈0.5%): Minimal effect, as dissolved salts pass through the filter.
4. COD/BOD Reduction (COD 3.6% & BOD 1.7%): Minor, mostly due to removal of colloidal and fine particulate organics.
5. Overall: MGF serves as a polishing step after secondary clarification, improving water clarity but not significantly reducing dissolved organic load.

8.RO-I feed water Quality. Table.NO-15

Source	RO-I feed water Quality
Inlet 10.12.2025	Flow rate @5.75m3/hr
pH	8.2
TSS	10 mg/lit
TDS	1708mg/lit
COD	27.55 mg/lit
BOD	20.0 mg/lit
Inlet 11.12.2025	Flow rate @5.78m3/hr
pH	7.96
TSS	10mg/lit
TDS	1738mg/lit
COD	22.25mg/lit
BOD	21.0mg/lit
Inlet 12.12.2025	Flow rate @ 5.79 m3/hr
pH	8.11
TSS	12mg/lit
TDS	1510 mg/lit
COD	22.00mg/lit
BOD	19.00 mg/lit

Pollution Load Reduction

- TDS: 96% removal
- COD/BOD: 92% removal
- TSS: 99% removal
- Observation: The RO system is highly effective in reducing pollutant loads, making the permeate suitable for reuse or safe discharge.

6. Operational Recommendations

1. Monitor Recovery & Flows: Maintain 70–75% recovery to prevent scaling. High TDS feed may require anti-sealant's.
2. Pre-Treatment: Ensure proper filtration (5 µm or less) to prevent fouling by suspended solids. pH adjustment may be needed if feed pH rises.
3. Cleaning: Periodic CIP (cleaning in place) may be necessary if COD/BOD cause biofouling.
4. Brine Management: Concentrate should be monitored for discharge. High TDS and organics could pose environmental issues.
5. Performance Tracking: Regularly check TDS, COD, and BOD in permeate to ensure membrane efficiency.

Complete RO -1Performance Table No-16 (75% Recovery)

Date	Feed Flow (m^3/hr)	Permeate Flow (m^3/hr)	Reject Flow (m^3/hr)	Feed TDS	Permeate TDS	Reject TDS	TDS Reduction %	COD Reduction %	BOD Reduction %	TSS Reduction %
10.12.2025	5.75	4.31	1.44	1708	68.3	1503	96%	92%	92%	99%
11.12.2025	5.78	4.34	1.45	1738	69.5	1530	96%	92%	92%	99%
12.12.2025	5.79	4.34	1.45	1510	60.4	1329	96%	92%	92%	99%

Technical Observations – RO-II

1. Permeate Quality:
   - TDS ~53–61 mg/L, very low, suitable for industrial or potable reuse.
   - RO-II effectively removes remaining salts from RO-I rejects.
2. Reject Concentration:
   - TDS rises significantly: 2889–3326 mg/L due to double concentration from RO-I and RO-II.
   - Reject water management is critical to prevent scaling, environmental pollution, or brine disposal issues.
3. Flow Reduction:
   - Permeate ~0.79 m^3/hr, significantly smaller than RO-I permeate (~4.3 m^3/hr).
   - Concentrate ~0.65 m^3/hr, carrying the bulk of TDS from RO-I.
4. System Considerations:
   - High TDS reject (>3000 mg/L) may require anti-scalants, pH adjustment, or brine disposal planning.
   - RO-II feed is already moderately saline; periodic membrane cleaning may be needed to prevent scaling or fouling.
   - Recovery (55%) is reasonable to limit TDS concentration and avoid exceeding membrane limits.
5. Pollution Load Reduction:
   - Additional ~96% TDS removal in RO-II permeate.
   - Overall system (RO-I + RO-II) reduces TDS in permeate from feed 1510–1738 mg/L down to ~53–61 mg/L.

RO-II water Quality. Table.No-17

RO-II (55% Recovery)

Date	Feed to RO-II (m^3/hr)	Permeate (m^3/hr)	Reject (m^3/hr)	Feed TDS	Permeate TDS	Reject TDS
10.12.2025	1.44	0.792	0.648	1503	60.1	3265
11.12.2025	1.45	0.798	0.653	1530	61.2	3326
12.12.2025	1.45	0.798	0.653	1329	53.2	2889

Technical Observations – RO-II

1. Permeate Quality:
   - TDS ~53–61 mg/L, very low, suitable for industrial or potable reuse.
   - RO-II effectively removes remaining salts from RO-I rejects.
2. Reject Concentration:
   - TDS rises significantly: 2889–3326 mg/L due to double concentration from RO-I and RO-II.
   - Reject water management is critical to prevent scaling, environmental pollution, or brine disposal issues.
3. Flow Reduction:
   - Permeate ~0.79 m^3/hr, significantly smaller than RO-I permeate (~4.3 m^3/hr).
   - Concentrate ~0.65 m^3/hr, carrying the bulk of TDS from RO-I.
4. System Considerations:
   - High TDS reject (>3000 mg/L) may require anti-scalants, pH adjustment, or brine disposal planning.
   - RO-II feed is already moderately saline; periodic membrane cleaning may be needed to prevent scaling or fouling.
   - Recovery (55%) is reasonable to limit TDS concentration and avoid exceeding membrane limits.
5. Pollution Load Reduction:
   - Additional ~96% TDS removal in RO-II permeate.
   - Overall system (RO-I + RO-II) reduces TDS in permeate from feed 1510–1738 mg/L down to ~53–61 mg/L.

Technical Observations – Two-Stage RO

1. Performance:
   - Total recovery = 5.126 / 5.77 ≈ 88.8% of feed converted to permeate.
   - TDS reduction ~96% – very efficient two-stage RO system.
2. RO-I Observations:
   - Good average recovery: 4.33/5.77 ≈ 75%
   - Permeate TDS 66 mg/L – suitable for reuse.
   - Reject (~1.44 KL/hr) is ideal for RO-II feed.
3. RO-II Observations:
   - Recovery ~0.796/1.44 ≈ 55%
   - Permeate TDS 60 mg/L – excellent quality.
   - Reject (~0.651 KL/hr, TDS 3100 mg/L) is highly concentrated; proper disposal or brine treatment is critical.
4. System Recommendations:
   - Maintain RO-I recovery ~75% and RO-II ~55% to prevent scaling.
   - Periodic cleaning for both stages due to moderate COD/BOD in feed.
   - Monitor TDS, pressure drops, and flow rates to avoid membrane damage.
   - Brine management for RO-II reject is essential; could consider evaporation, zero-liquid discharge (ZLD), or blending with lower TDS streams.

Two-Stage RO Table.NO-18

Stage	Feed Flow (KL/hr)	Permeate Flow (KL/hr)	Permeate TDS (mg/L)	Reject Flow (KL/hr)	Reject TDS (mg/L)
RO-I	5.77	4.33	66.06	1.44	1454
RO-II	1.44	0.796	60	0.651	3100
Total System Permeate	5.77	5.126	65	0.651	3100

9.Treated Water Re-Used (Table 19)

S.NO	Purpose	Recycled Water Used (KLD)
1	Process	526
2	Cooling tower make-up	123.02
3	Boiler feed	-
4	DM & softener	-
5	CO2 Plant	-
6	Domestic	-
	Total	649.02

Observations:

- Maximum recycled water is used for Process (526 KLD), followed by Cooling tower make-up (123.02 KLD).
- Boiler, DM & softener, CO_2 plant, and domestic uses have no recycled water during the study period.
- Total recycled water usage is 649.02 KLD.

10. Overall Performance of Wastewater Treatment System (Table 20)

Parameters	Before Treatment (mg/L)	After Treatment (mg/L)	% Reduction
Total Wastewater Generation	722.24 KLD	Treated: 649.02 KLD	89.86%
TDS	1930.66	65.0	96.63%
TSS	495.33	10.66	97.84%
COD	2770.66	23.93	99.13%
BOD	980	20.0	97.95%

Observations:

- Treated wastewater for recycling: 649.02 KLD out of 722.24 KLD generated → ~89.86% of wastewater is being reused.
- Treatment efficiency is very high:
  - TDS reduced by 96.63%
  - TSS reduced by 97.84%
  - COD reduced by 99.13%
  - BOD reduced by 97.95%
- This indicates that the wastewater treatment plant is performing extremely well and producing water suitable for process and cooling tower reuse.

Key Takeaways

1. High Water Reuse: Nearly 90% of wastewater is recycled, reducing freshwater demand significantly.
2. Excellent Treatment Efficiency: All major pollution indicators (TDS, TSS, COD, BOD) are reduced by over 95%.
3. Primary Use: Most recycled water is used in industrial processes and cooling tower make-up, which are non-potable applications.
4. Potential Improvement: Explore using treated water for boiler feed, DM & softener, CO_2 plant, or domestic use to further conserve freshwater.

. The chemical and power consumption during the study period:

Chemicals Consumption

1. Lime (for pH adjustment): Average consumption: 41.66 kg/day
2. Polyelectrolyte: Average consumption: 0.05 kg/day
3. Alum: Average consumption: 10.0 kg/day
4. Anti-Scalent: Average consumption: 10.0 kg/day
5. Hydrochloric Acid (HCl): Average consumption: 58.0 liters/day
6. Sodium Metabisulfite (SMBS): Average consumption: 1.3 kg/day
7. Hypochlorite (Hypo): Average consumption: 32.3 kg/day

Power Consumption

- Average power consumption: 1350 units/day

Based on the above assessment, the following consolidated conclusions are drawn:

1. The distillery has successfully implemented a comprehensive Zero Liquid Discharge (ZLD) system in line with CPCB and TGPCB guidelines, and no liquid effluent is discharged outside the factory premises under normal operating conditions.
2. All wastewater streams are effectively segregated, treated, and managed through appropriate unit operations, including UASB, extended aeration, clarification, tertiary filtration, two-stage RO, Multiple Effect Evaporator (MEE), and Decanter systems.
3. Spent wash (≈578 KLD) and RO rejects (≈18 KLD) are 100% treated through MEE followed by decanting, achieving solids concentration up to 90%, resulting in the generation of DDGS (~70 TPD), which is utilized as a valuable by-product.
4. The MEE condensate recovery of approximately 526 KLD, which is completely reused in the process, demonstrates high water recovery efficiency (~88.7%) and significantly reduces fresh water consumption.
5. The biological treatment systems (UASB and Aeration Tanks) are operating in a stable and efficient manner, with satisfactory reduction of BOD, COD, and TSS, and with healthy biomass activity, as evidenced by MLSS, MLVSS, SVI, DO, and VFA values.

6. The two-stage Reverse Osmosis system exhibits excellent performance, achieving overall reductions of approximately:
    - TDS: ~96.6%
    - COD: ~99.1%
    - BOD: ~98.0%
    - TSS: ~97.8%

   The RO permeate quality is suitable for reuse in process and cooling tower make-up, further strengthening ZLD compliance.

7. Overall wastewater treatment efficiency of ~89.86% recycling has been achieved during the study period, with treated water fully reused within the plant for industrial purposes.
8. Chemical and power consumption during the study period were found to be within normal and acceptable operating limits, indicating optimized and controlled system operation.
9. No abnormal fluctuations in wastewater quantity, quality, or treatment system performance were observed during the audit period, confirming consistent and reliable plant operation.

Final Conclusion

Based on the above findings, it is concluded that the Zero Liquid Discharge system of M/s Allied Blenders & Distillers Limited is technically adequate, environmentally compliant, and operationally efficient. The system effectively meets the objectives of water conservation, pollution load reduction, and sustainable waste management, fully complying with the applicable CPCB and TGPCB ZLD norms. The ZLD facility is fit for continued operation, and the plant demonstrates a strong commitment to environmental protection, regulatory compliance, and sustainable industrial practices.

Summary of Wastewater Treatment Plant Equipment Table NO-21

S.NO	Equipment	Qty	Key Specs/Details	Make / Model
1	Bar Screen	1 No	Size: 1000x600 mm, Material: SS304	MWM
2	Effluent Transfer Pump	2 Nos (1W+1S)	Capacity: 25 m^3/hr, Head: 10 m, Horizontal centrifugal, 2.2 kW / 2900 RPM	Kirloskar
3	Alum Dosing Pump	1 No	Capacity: 35 LPH, Mechanically actuated diaphragm, Max pressure 4 kg/cm^2	Milton Roy
4	Agitator (Coagulation Tank)	2 Nos	Two-blade pitched, 200 mm dia x 400 mm width, 100 RPM	MWM
5	Neutralization Tank	1 No	Size: 3.3 x 5 x 3 m, Capacity: 50 KL	-
6	UASB Reactor	1 No	Diameter: 10 m, Height: 9 m, Capacity: 700 KL	-

S.NO	Equipment	Qty	Key Specs/Details	Make / Model
7	Clarifier	1 No	Capacity: 100 KL, Size: 6.5 m dia x 3 m height	-
8	Aeration Tank I	1 No	Size: 13.6 m dia x 4 m height, Capacity: 580 KL	-
9	Aeration Tank II	1 No	Size: 7 x 4 x 2.85 m, Capacity: 80 KL	-
10	Primary Tube Settler	1 No	Tube plan area: 9 m^2, Size: 3 x 3 m + 2.1 m height + 0.4 m fb	MWM
11	Primary Sludge Transfer Pump	1 No	Capacity: 10 m^3/hr @ 10 m head, 0.75 kW / 2760 RPM	Kirloskar
12	Filter Feed Pumps	2 Nos (1W+1S)	Capacity: 21 m^3/hr @ 30 m head, 5 HP / 2900 RPM	Kirloskar
13	Pressure Sand Filter	1 No	Flow: 25 m^3/hr, Diameter/Height: 1300/1500 mm, Filtration rate: 16 m^3/m^2/hr	MWM
14	Activated Carbon Filter	1 No	Flow: 25 m^3/hr, Diameter/Height: 1300/1500 mm, Filtration rate: 16 m^3/m^2/hr	MWM
15	Coarse Bubble Diffuser	12 Nos	Size: 4” Dia, Material: EPDM	W2P or Equivalent
16	Media for Pressure Sand Filter	-	Fine sand (0.2-0.3 mm): 350 kg, Fine sand (0.5-1.0 mm): 1050 kg, Fine silex (6-3 mm): 350 kg, Gravels (12-6 mm): 350 kg, Pebbles (25-12 mm): 600 kg	-
17	Media for Activated Carbon Filter	-	Activated carbon: 350 kg, Fine sand (0.5-1.0 mm): 350 kg, Fine silex (6-3 mm): 350 kg, Gravels: 350 kg, Pebbles (25-12 mm): 600 kg	-
18	pH Meter	1 No	Range: 0-14, Tank mounted	Aster
19	Pressure Gauge	1 Lot	-	-
20	Electromagnetic Flow Meter	2 Nos	Flow: 25 m^3/hr, Size: 65 NB	Adept
21	UF Feed Tank	1 No	Capacity: 50 KL, Size: 4 m dia x 4 m height	-
22	UF Feed Pump	2 Nos (1W+1S)	Capacity: 40 m^3/hr @ 30 m head, 7.5 HP / 2900 RPM	Kirloskar
23	Hypo Dosing Pump	1 No	Capacity: 5 LPH	Milton Roy
24	Caustic Dosing Pump	1 No	Capacity: 380 LPH	Milton Roy
25	Acid Dosing Pump	1 No	Capacity: 170 LPH	Milton Roy
26	Dosing Tanks	3 Nos	Capacity: 1000 L each	Sintex
27	UF Membrane	10 Nos	Hollow type UF Model SFP2880	DOW

S.NO	Equipment	Qty	Key Specs/Details	Make / Model
28	UF Permeate/Backwash Tank	1 No	Capacity: 120 KL, Size: 5.7 m dia x 4.7 m height	-
29	RO-I Feed Pump	2 Nos (1W+1S)	Capacity: 60 m^3/hr @ 30 m head, 9.2 kW / 2900 RPM	CNP
30	Antiscalant, Acid & SMBS Dosing Pumps	3 Nos	Capacity: 6 LPH each	Milton Roy
31	Micronic Cartridge Filter	1 No	Capacity: 60 m^3/hr	MWM
32	HP Pump	2 Nos (1W+1S)	Capacity: 60 m^3/hr @ 120 m head, 30 kW / 2900 RPM	Grundfos
33	RO Membrane Housing	10 Nos	Pressure: 300 PSI, Size: 8" dia x 3 elements	Pentair
34	Membranes in 1st Array	36 Nos	Diameter/Length: 8"/40"	DOW
35	Membranes in 2nd Array	24 Nos	Diameter/Length: 8"/40"	DOW
36	RO Permeate Tank	2 Nos	Capacity: 125 KL each	MWM
37	RO Reject Storage Tank	1 No	Capacity: 100 KL	MWM
38	RO Stage-II Pressure Feed Pump	2 Nos (1W+1S)	Capacity: 20 KL/hr @ 30 m head	CNP
39	RO Reject Water Storage Tank	1 No	Capacity: 50 KL	MWM
40	Antiscalant & Acid Dosing Pumps	2 Nos	Capacity: 6 LPH each	Milton Roy
41	Micron Cartridge Filter	1 No	5 micron	MWM
42	HP Pump	2 Nos (1W+1S)	Capacity: 17.4 KL/hr @ 30 m head, 40 HP / 1440 RPM	-

Notes:

- (1W+1S) indicates 1 working + 1 standby pump for reliability.
- Most pumps are horizontal centrifugal type with self-priming features.
- Major equipment manufacturers: MWM, Kirloskar, Milton Roy, DOW, Grundfos, CNP, Pentair.
- The plant uses a combination of UASB, aeration tanks, clarifiers, pressure filters, UF & RO membranes for efficient treatment.
- Various dosing pumps for chemical treatment ensure proper pH adjustment and coagulation.
- Media details for filters and diffusers indicate well-designed filtration and aeration systems

EVAPORATION SECTION

Summary of Evaporator & Condensate Equipment. Table .NO-22

Sr.No	Equipment	Description	MOC	Qty
1	Evaporator	Designed on Falling Film Calandria Principle	Shell: AISI 304	3
		Shell & Tube Construction	Tubes: AISI 304	
		Tube Sheet: AISI 304		
2	Evaporator	Designed on Forced Circulation Principle	Shell: AISI 304	3
		Shell & Tube Construction	Tubes: AISI 316	
		Tube Sheet: AISI 304		
3	Vapor Liquid Separator	Vertical construction with tangential entry for effective vapor separation	AISI 304	3
4	Surface Condenser	Shell & Tube Type	Shell: AISI 304	3
		Tubes & Tube Sheet: AISI 304		
5	Feed Tank	Vertical, Praj standard, 30 minutes retention time	AISI 304	2
6	Process Condensate	Vertical, Praj standard	AISI 304	2
7	Steam Condensate Tank	Vertical, Praj standard	MS (Mild Steel)	3
8	Process Condensate Pump	Centrifugal Type	CF8 (wetted parts)	1 + 1 (Standby)
9	Steam Condensate Pump	Centrifugal Type	CI (Cast Iron)	1 + 1 (Standby)
10	Feed Pump + Motor	Centrifugal Type	CF8 (wetted parts)	1 + 1 (Standby)

Notes:

- CF8: Stainless steel casting grade (used for wetted parts in pumps).
- CI: Cast Iron.
- AISI 304 & 316: Stainless steel grades, with 316 offering better corrosion resistance, especially in tubes of forced circulation evaporators.
- 1 + 1 indicates one working and one standby pump for operational reliability.
- Praj Standard likely refers to equipment design specifications by Praj Industries, a known manufacturer.

Plant lay out