BEFORE THE HON'BLE NATIONAL GREEN TRIBUNAL SOUTHERN ZONE BENCH AT CHENNAI

Original Application No. 33 of 2023 (SZ)

Nukatati Rajasekhar & another .... Applicants

-Vs-

Union of India,
Through its Secretary,
Ministry of Environment Forest and CC
& 6 others ... Respondents

INDEX OF DOCUMENTS FILED BY 7TH RESPONDENT IN SUPPORT OF SUBMISSIONS TO THIS HON'BLE TRIBUNAL'S DIRECTIONS DATED 11.12.2024

Certified that the above documents are true copies of its originals

Dated at Chennai on this the 12th day of February, 2025

Counsel for 7th Respondent

REPORT

ZERO LIQUID DISCHARGE IN WOOD & AGRO BASED PULP & PAPER MILLS – RELEVANCE & FEASIBILITY IN INDIAN PERSPECTIVE

Sponsored By

INDIAN PAPER MANUFACTURERS ASSOCIATION
New Delhi

Prepared By

Central Pulp & Paper Research Institute
Saharanpur, (U.P.), India

JULY, 2022

CONTENTS

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About Central Pulp & Paper Research Institute (CPPRI)

CPPRI is a premier research institute under Ministry of Commerce & Industry , Government of India, dedicated to the services of Pulp & Paper Industry. Located at Saharanpur , Uttar Pradesh , the institute has state of art laboratories and facilities with trained , dedicated and highly experienced scientists to carry out quality research work and render technical and consultancy services in various areas of paper making including Environmental Management.

About Environmental Management Division , CPPRI

The Environmental Management Division of CPPRI is NABL accreditated for analysis of water and waste water, ambient air monitoring and stack emissions monitoring. The division is recognized by various regulatory authorities, pulp, paper and allied industries as a centre of expertise in context of environmental monitoring and addressing various environmental issues related to Pulp & Paper Industry. The division has world class facilities and expertise to carry out R& D as well as render technical and consultancy services related to ETP performance evaluation and adequacy assessment, ETP upgradation / trouble shooting , Environmental Audit, Water Audit , Air monitoring etc

The division serves as a nodal agency to assist Central Pollution Control Board (CPCB) in reviewing and revision of environmental discharge and emission norms for Indian Pulp and Paper Industry, Generation of data base on pollution load generated by Indian pulp and paper industry and various issues related to environmental sustainability of Indian Pulp & Paper Industry. The Environmental Management Div has also assisted CPCB in preparation and successful implementation of "Charter on Water Recycling & Pollution Prevention in Pulp & Paper Industry of Ganga River Basin in Pulp & Paper Mill of Uttar Pradesh and Uttarakhand" . Presently the division is assisting CPCB as third party in monitoring of Grossly Polluting Industries in the River Ganga & Yamuna Basin since last 5 years

Executive Summary

In recent times, specially in context of efforts for rejuvenation of river Ganga & its tributaries as well as other major rivers in the country, there has been an increasing pressure on industries including pulp and paper mills to reduce / totally eliminate the discharge of effluent / waste water generated into the recciving stream by total reuse / recycling of treated effluent i.e. Zero Liquid Discharge (ZLD). While some of the RCF based pulp and paper mills producing kraft paper have switched over to ZLD by closing the water loop without any major technological intervention, they have to compromise in terms of product quality, process operation efficiency and productivity, wire and felt life etc., due to build up of Total Dissolved Solids (TDS) , Chemical Oxygen Demand (COD) and Biological OxygenDemand (BOD) and other recalcitrants due to closure of water/ back water circuit.Not with standing this fact that only a few RCF based kraft paper mills have gone for ZLD without any major technology intervention and thus compromising their product quality and moreover there is no colour / brightness issue in kraft paper, several State Pollution Boards have already started asking timeline for achieving ZLD from wood based and agro based writing & printing paper mills at time of renewal of consent to operate. It is in this perspective, this study on **Zero Liquid Discharge In Wood & Agro Based Pulp & Paper Mills – Relevance & Feasibility in Indian Perspective** has been awarded by **Indian Paper Manufacturers Association(IPMA)** to **Central Pulp & Paper Research Institute (CPPRI)** , a premier research institute in field of pulp & paper to explore the relevance and feasibility of ZLD in wood based and agro based pulp and paper mills in Indian Perspective .

The study comprises of six chapters

Chapter 1 titled **Back Ground of the Study** describes the background for taking up the study as indicated above and the methodology adopted for carrying out this study.

Chapter 2 i.e. **Indian Paper Industry - An Introduction** covers the general profile of Indian Pulp and Paper Industry and various categories of pulp and paper mills in operation in the country along with important and relevant statistical data as well as highlights the diversity of Indian Paper Industry in terms fibrous raw materials used , end products , scale of operation which influences the fresh water consumption from mill to mill . The general pulp & paper making process employed in wood & agro based pulp and paper mills for paper making i.e. from raw material prepartion to finished product including chemical recovery and effluent treatment is also summarised as **Annexure - I .**

Chapter 3 on **Fresh Water Consumption - Current Status & Benchmarks** highlights the minimum fresh water consumption needed by Wood & Agro based Pulp & Paper Mills producing writing & printing grade of paper estimated through an extensive water and material balance **(Annexure –II)** carried out for a writing and printing paper mill having both straw fiber line as well as wood fiber line with ECF bleaching sequence The study indicates that the fresh water requirement in an integrated pulp and paper mill with state of art modern fiber line technology in terms of pulping , bleaching , fiber recovery etc is generally around 40 – 45 m^3 / t_{paper} . The data / information received through questionnaire prepared in context of prepartion of the report , the fresh water consumption in some of the major pulp and paper mills also indicate similar trends.

Chapter 4 covers **Zero Liquid Discharge (ZLD) Concept, Evolution and Technology Options .** As indicated in the chapter Zero Liquid Discharge (ZLD) is a system consisting of unit processes or unit operations or their combination, such that there is no discharge of liquid effluent from an industry, process plant, etc. ZLD status of a unit is a reflection of the fact that the effluent generated is effectively treated, recycled and reused by the mill / unit and no liquid is discharge outside its premises. Zero liquid discharge is generally accomplished by concentrating the wastewater through various technologies together with membrane-based and multi effect evaporation-based systems. The chapter covers the merits / limitation of various technologies available for facilitating ZLD like **Membrane Bio-Reactor Technology (MBR), Ultra-filtration/Reverse Osmosis, Evaporation Technologies, Agitated Thin Film Dryer (ATFD)** and **Incinerator.** The major drivers , challenges and options for ZLD are also covered in this chapter

Under Chapter 5 on **Techno-Economic Feasibility of ZLD – Indian Paper Industry Perspective** , techno –economics of a proposed ZLD system involving **Flash Mixer, DAF followed by Clarifier and subsequently combination of Ultra Filtration , Nano Filtration and Reverse Osmosis, Evaporation and Crystallization** in Indian Paper Industry perspective has been evaluated theoretically inputs from technology suppliers and Pulp & Paper mills. Under the study initially the estimated cost of treatment for 100 m^3/hr treated effluent using combination of above technologies has been calculated and then the cost of treatment for pulp and paper mills with 100 , 250 and 500 tpd production capacity has been calculated separately **. The additional cost for ZLD has been estimated to be around Rs 145 / m^3 which is difficult to absorb in cost of production** . This techno-economics study indicates the implementation of ZLD concept through standalone effluent treatment facility would render the mills unviable to operate.

The **Final Chapter 6** summarizes major observations of the study which are as under:

- In recent years the Large Integrated Pulp & Paper Mills (Wood & Agro based) producing writing and printing grade of paper and paper boards have made significant improvement in their technological and environmental status making substantial capital investment.

- In last 5-10 years the mills have made significant investments for adoption of latest modern fiber line **Best Available Technologies / Best Practicable Technologies/ Bare Minimum Technologies** to improve their technological and environmental status, cost competitiveness and significant improvement in process efficiency and product quality.

- A summarised status of major technologies adopted by these mills is as under :

Technology	% of Mills
Wet Washing of Agro Residues with back water / treated effluent	**100 %**
Continuous Digester for Pulping of Agro Residues	**100 %**
New Generation Pulp Washer (Press etc)	**50- 60 %**
Elemental Chlorine Free Bleaching (ECF)	
Wood	**100 %**
Agro	**80-90 %**
Total Chlorine Free Bleaching (TCF)	**1Mill**
Fiber Recovery System	**100%**
Chemical Recovery	**100 %**
Effluent Treatment Plant up to Tertiary Treatment	**90%**
Biomethanation for Wet washing (in Mills using Agro residues)	**All mills**
Lime Kiln (wood based)	**All Mills**
Sludge Dewatering Systems	**All Mills**

- Even though the capability of ZLD for waste minimization, resource recovery, wastewater treatment and mitigation of potential impacts on water quality of receiving streams is theoretically studied, their application on mill scale are limited due to very high capital cost, increased energy consumption and uncertainty about the final outcome

- Moreover , the available literature survey carried out in context of preparation of the report also substantiate the fact that there is no reported reference of ZLD of mill scale ZLD system operational in pulp and paper mills any where in the world which indicates its practical unfeasibility / unviability in the existing scenario . Data / information of some national / international reports referred are shared as under :

Reference	**Data / information**
World Bank IFC Environmental , Health & Safety Guidelines , Pulp and Paper Mills Good International Industry Practices (GIIP) Table 1(a) – Effluent Guidelines for Pulp & Paper Facilities – Bleached Pulp Kraft Integrated , page 26 **(Annexure –III)**	The effluent discharge for best achieved are given as 50 m^3/ ADT bleached kraft pulp
IL& FS EIA Guidelines published by Ministry of Environment & Forests , March 2010 , page 3-46 , Table 3- 30 **(Annexure –IV)**	The global best achieved specific water consumption is given as 41.8 / BDMT pulp
Sustainability report of Confederation of European Industries (CEPI) 2013 **(Annexure –V)**	92% of the treated effluent is discharged to surface water which implies no mill in Europe is a ZLD mill. It also shows that there is no ZLD restrictions in European industry.

Techno-economic feasibility of Implementation of ZLD for Water Polluting Industries (CPCB Report 2015)) **(Annexure –VI)**	• For the present Zero Liquid Discharge is techno-economically not feasible for most of the mill categories, No country has therefore imposed a ZLD condition for the paper industry. • Pulp & Paper Industry world wide has been exploring the ZLD concept over last two decades but has not been able to identify a technically feasible, economically viable and sustainable technology to achieve ZLD . • The two possible options which have been explored are : (a) Close up as process water loops by total recycling inside a process sequence or into different process sequence within the mill (b) Treat the effluent in a stand alone facility to render a suitable process reuse and volume reduction

- The options indicated in the above mentioned CPCB report are unviable as:
- Closing process loops without technology intervention will result in deterioration of product quality due to build up of TSS , TDS , COD etc as well as increased pollution load at ETP.
- Alternatively setting up stand alone facility comprising of Ultra ,Nano & Reverse Osmosis and Multiple Effect evaporater are highly energy intensive and economically non viable . An approximate theoretical estimate

of operating cost of ZLD system as indicated in **Chapter 5** is around **145 / m^3**. Such an elaborate set up for any pulp and paper industry will be huge and complex and not practically implementable in context of scale of operation of most of the large pulp and paper mills.

  - The performance of a small pilot plant for ZLD system incorporating treatment of tertiary treated effluent through combination of membrane technology , MVR & AFTD installed by an agro based paper mill looks promising in terms of reduction in TDS , COD, Color and recovery of water .

  - However, it has several operational issues including inconsistent operations, scale build up , frequent choking of membranes, disposal of sludge etc and looks unviable.

  - Also the operating cost is still quite high for Pulp & Paper Mills to absorb in Indian perspective even if it is considered as an option.

- Though the propagation of concept of **Zero Liquid Discharge in Pulp & Paper Industry** by regulatory authorities is welcome in principle in context of water conservation but it has several practical limitations / bottlenecks specially in context of paper mills producing writing and printing grade of paper and boards and speciality papers due to adverse impact in process operations and product quality (without technological intervention) and techno-economic feasibility of available ZLD systems (with technological intervention).

- The adoption of technologies like membrane technologies along with MVR for achieving Zero Liquid Discharge is to be looked through prism of techno economic feasibility specially in Indian perspective where the mills operate on a wide range of scale of operation , use diverse raw materials and wide spectrum of paper products produced by the same mill.

- In context of membrane filtration system energy requirements along with other related expenses are much higher than conventional wastewater treatment and disposal option.

- Further most of the ZLD related technologies consume valuable resource like (energy , and chemicals) which itself has cross medium environment impact including carbon emissions.

- Thus there is a need to find alternatives to energy-intensive evaporator/crystallizer systems which is not proven at commercial scale. Application of kidney technologies like membrane filtration system (ultra filtration / reverse osmosis) is also associated with problems of disposal of mother liquor and salts for which cost effective solution is yet to be explored nor there are any existing waste management facilities which can receive these mother liquor and salts for environmentally safe disposal.

- Further in terms of environmental concerns, more studies are needed for life-cycle assessment of energy demand and greenhouse gas emissions to improve understanding of the cost-benefit of ZLD systems.

- Use of diverse fibrous raw materials and producing different grades of products makes the optimisation of water consumption really challenging. More over mills producing speciality grade / food packaging / hygienic paper products require extremely high standard of process water quality as well as cleaning of paper machines and equipments which makes ZLD almost impossible

- It is also to be noted that in some drains / tributaries(which are seasonal) the pulp & paper mill treated effluent discharged is used in down stream by farmers for irrigation. Over emphasis on ZLD may impact the availability of water to farming community accordingly

- Most of the Large Pulp & Paper Mills are supporting the farmer community by providing treated effluent for irrigation / cultivation thus indirectly aiding in saving fresh water consumtion for agriculture . Many Pulp & Paper Mills have even facilitated network of irrigation for providing treated effluent to local farmers. However , this depends on the location of the mill , availability of land and involvement of framers, type of crops, requirement of farmers and local environment.

- Most of the receiving streams in India are seasonal with lean flow during most of the year. In some cases the discharge from pulp and paper industry is the only source for dilution of pollution load from different sources (Municipal Sewage / House Hold Waste etc) in the river.

- To encourage ZLD there is a need for a pilot scale demonstration of appropriate ZLD technologies / systems such as membrane filtration , crystallization , ozone treatment as advocated by regulators / policy makers for evaluation of their relevance , applicability as well as suitability in Indian context without jeopardizing the competiveness of the industry.

- Recently a fresh attempt is being made under a **UNIDO Paper Project Phase II - A Firm-level Demonstration of Technologies and Productivity Enhancement for the Pulp and Paper Industry** to demonstrate feasibility of Membrane Filtration in Indian Pulp & Paper Industry . Under the project skid mounted pilot scale reactor employing ultra filtration and nano filtration modules is being developed to conduct trials for treatment of various specific stream like paper machine back water, secondary clarifier outlet , E stage bleach plant effluent etc in selected pulp and paper mills of using diverse raw materials (wood , agro and RCF based) across the country to evaluate its feasibility and techno-economic viability in context of significant reduction in fresh water consumption , waste water discharged and pollution load in recent years . The Pre-Pilot Trials in an agro based pulp & paper mills has already been initiated and the pilot scale trials are likely to be undertaken soon.

- There is a need for incentivisation and recognition of the pulp and paper mills (including other industries) achieving / setting up new benchmarks in area of water conservation or contributing significantly towards reduction in water footprint, increase in ground water level etc. Further various incentive-based instruments such as subsidies / tax or duty exemptions on technologies / equipments facilitating ZLD are required to encourage pulp and paper mills to consider adoption of ZLD once it is proven through pilot plant and scale up operation studies.

- The Pulp & Paper Industry in recent years have invested significantly to adopt BMT / BPT / BAT to meet the stringent fresh water consumption & waste water discharge norms as well as pollution norms under the CPCB Charter. No doubt while regulations are necessary for addressing the environmental impact, directives for ZLD without any feasibility study could also hamper the industry's growth and sustainability.

- In all at present , ZLD is still an evolving concept / technology specially in context of Pulp & Paper sector. There is still no reported example of mill scale operation of zero liquid discharge system in pulp and paper mills producing writing and printing grade of paper . Thus there is a need for evaluation / demonstration of techno- economic feasibility of appropriate ZLD systems on following counts before ZLD is made mandatory.

- Extent of water recovery possible
- Sustainability on basis of 24x7 operations
- Operation & Maintenance costs
- Upstream changes required
- Cross-media environmental impacts

x

- As such in present scenario minimum water fresh water consumption **of <50 m^3 / t paper for Chemical Pulp Mills producing Writing & Printing Grade of Paper from Wood & Agro residues Pulp & Paper Mills** seems to be justified in present scenario till techno –economically viable option for complete reuse / recycle of treated effluent is available.

- Till then the Pulp & Paper Mills should focus more on :

- Optimizing the fresh water consumption as there is still a scope of further reduction in fresh water consumption
- Color removal in treated effluent .
- Increase / recycle of various back water streams & treated effluent
- Wherever local conditions permit and practically possible, maximize treated water use for irrigation

BACKGROUND OF THE STUDY

Chapter 1

In recent times, specially in context of efforts for rejuvenation of river Ganga & its tributaries as well as other major rivers in the country there has been an increasing pressure on industries including pulp and paper mills to reduce / totally eliminate the discharge of effluent / waste water generated into the receiving stream by total reuse / recycling of treated effluent i.e. **Zero Liquid Discharge (ZLD).** While some of the RCF based pulp and paper mills producing kraft paper have switched over to ZLD by closing the water loop without any major technological intervention, they have to compromise in terms of product quality, process operation efficiency and productivity, wire and felt life etc., due to build up of **Total Dissolved Solids (TDS) , Chemical Oxygen Demand (COD) and Biological OxygenDemand (BOD)** and other recalcitrants due to closure of water/ back water circuit.

Not with standing this fact , that only a few RCF based kraft paper mills have gone for ZLD without any major technology intervention and thus compromising their product quality and mofreover kraft paper there is no colour / brightness issue, several State Pollution Boards have already started asking timeline for achieving ZLD from wood based and agro based writing & printing paper mills at time of renewal of consent to operate.

It is in this perspective, this study has been awarded by **Indian Paper Manufacturers Association(IPMA)** to **Central Pulp & Paper Research Institute** (CPPRI) , a premier research institute in field of pulp & paper to explore the relevance and feasibility of ZLD in wood based and agro based pulp and paper mills in Indian Perspective .

1.1 METHODOLOGY

The methodology adopted for carrying out the study and preparation of the report include :

- Kickoff Meeting between CPPRI Scientists & IPMA Technical Committee.

- Literature Survey / sourcing of information related to feasibility ZLD in Wood & Agro based pulp & paper mills.

- Preparation of questionnaire for collection of relevant data & information from various paper mills.

- Estimation of optimum fresh water requirement in various process operations of respective categories of pulp & paper mills.

- Water / Material Balance of pulp & paper mill in general .

- Bench marking of the fresh water consumption & waste water discharge in pulp & paper mills.

- Water quality requirements in various process operations for production of writing & printing / specialty grade of paper.

- Zero Liquid Discharge (ZLD) concept , basics & fundamentals, options , and limitation and implementation in Indian perspective.

- Evaluation of techno-economics of ZLD system (membrane filtration & other advanced treatment technologies) in Indian perspective.

INDIAN PAPER INDUSTRY – AN INTRODUCTION

Chapter 2

Paper is one of the most environmentally sustainable products as it is - **Bliodegradable, Recyclable, Renewable** and **produced from sources which are renewable and sustainable.** Indian Paper Industry is unique as it use diverse raw materials and produces diverse range of paper products .

On the basis of **raw materials used** the industry can be classified into :

- **Mills using Woody Raw Materials (+15 varieties of wood species used by pulp and paper mills)**
- **Mills using Non Wood Fibrous Raw material / Agro residues like Bagasse, Rice Straw, Wheat Straw, Grasses/Reeds**
- **Mills using Waste Papers / Recycled Fiber**

However, in today scenario , most of the mills are using mixed raw materials in fiber furnish depending upon raw material availablity to cater the production requirement and customer demand.

Based on the **end products** the industry can be broadly classified into :

- **Mills producing unbleached grade of paper (Kraft Paper / packaging grade of paper)**
- **Mills producing Bleached grade of Paper (Writing Printing / dUplex Board)**
- **Mills Producing Specialty Grade of Paper (Tissue , Food Grade etc)**

Recently while revising the environmental norms under **Charter for Water Recycling & Pollution Prevention in Pulp & Paper Industries of Ganga River Basin ,** CPCB broadly classified the mills into following categories

1. **Wood Based Pulp & Paper Mills producing Bleached Grade of Paper (Category A1)**
2. **Wood Based Pulp & Paper Mills producing Unbleached Grade of Paper (Category A2)**
3. **Agro based Pulp & Paper Mills producing Bleached Grade of Paper (Category B1)**
4. **Agro based Pulp & Paper Mills producing Unbleached Grade of Paper (Category B2)**
5. **RCF based Pulp & Paper Mills producing Unbleached Grade of Paper (Category C2)**
6. **RCF based Pulp & Paper Mills producing Bleached Grade of Paper (Category C1)**
7. **Mills producing Specialty Grade of Paper (Category D)**

2.1 INDIAN PAPER INDUSTRY – A BREIF PROFILE

The overall Indian Paper Industry Profile is summarized in **Table 2.1.**

Table 2.1 Profile of Indian Paper Industry(2020—2021)

No. of Mills		**900**
Total Installed Capacity, million tons		**29.11**
Operating Installed Capacity , million tons		**23.99**
Production of Paper, Paperboard and Newsprint , million tons		**21.36**
Capacity Utilization, %		**~89**
Operational Units		**526**
Per capita Consumption (kgs)		**15.63**
Contribution From Different Segments (million tons)		
Wood Based	**Agro Based**	**RCF Mills**
3.91	**1.16**	**16.29**

Source: Census Surbvey of Indian Paper Industry

The share in terms of percentage of overall production is indicated in **Fig 2.1.**

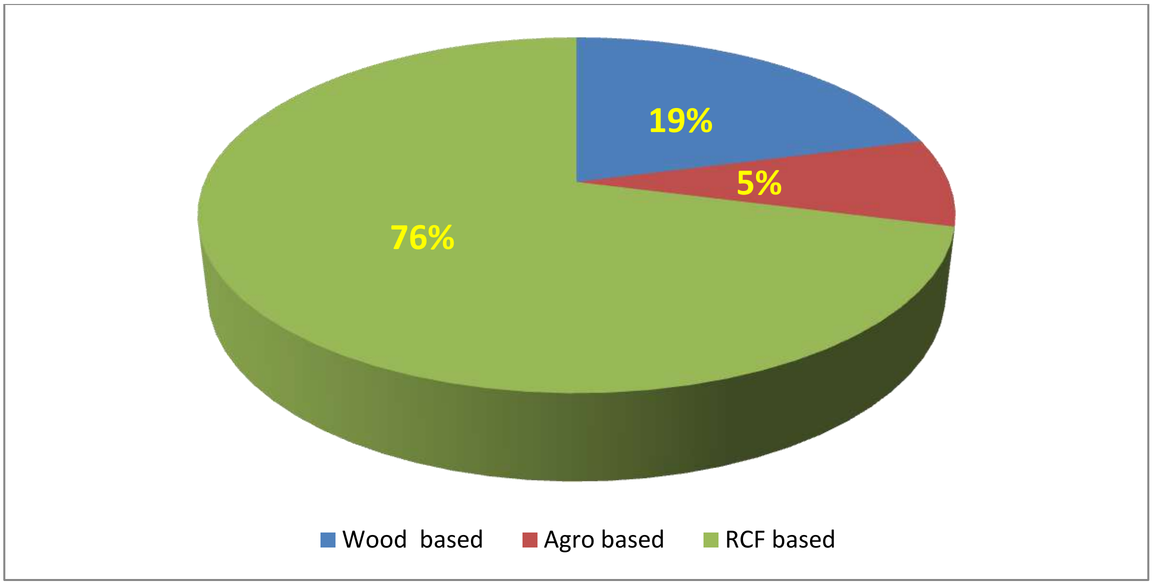

Fig 2.1 Percentage Paper Production Share (Raw Material Basis)

2.2 GENERAL PULP & PAPER MAKING PROCESS

The general pulp and paper making process is depicted in **Fig 2.2.** As indicated in this figure the pulp and paper making process comprise **of raw material preparation , pulping, washing of pulp , bleaching of pulp (for producing bleached grade of pulp) , stock preparation & paper machine.** As indicated in the figure most of the process operations are carried out using water as medium which is a basic requirement and most important resource for pulp and papermaking. Though pulp and paper making process is a water intensive process , but only 10% of the water is consumed during papermaking and the balance about 90 % of good quality water after treatment is normalyy discharged into the receiving streams.

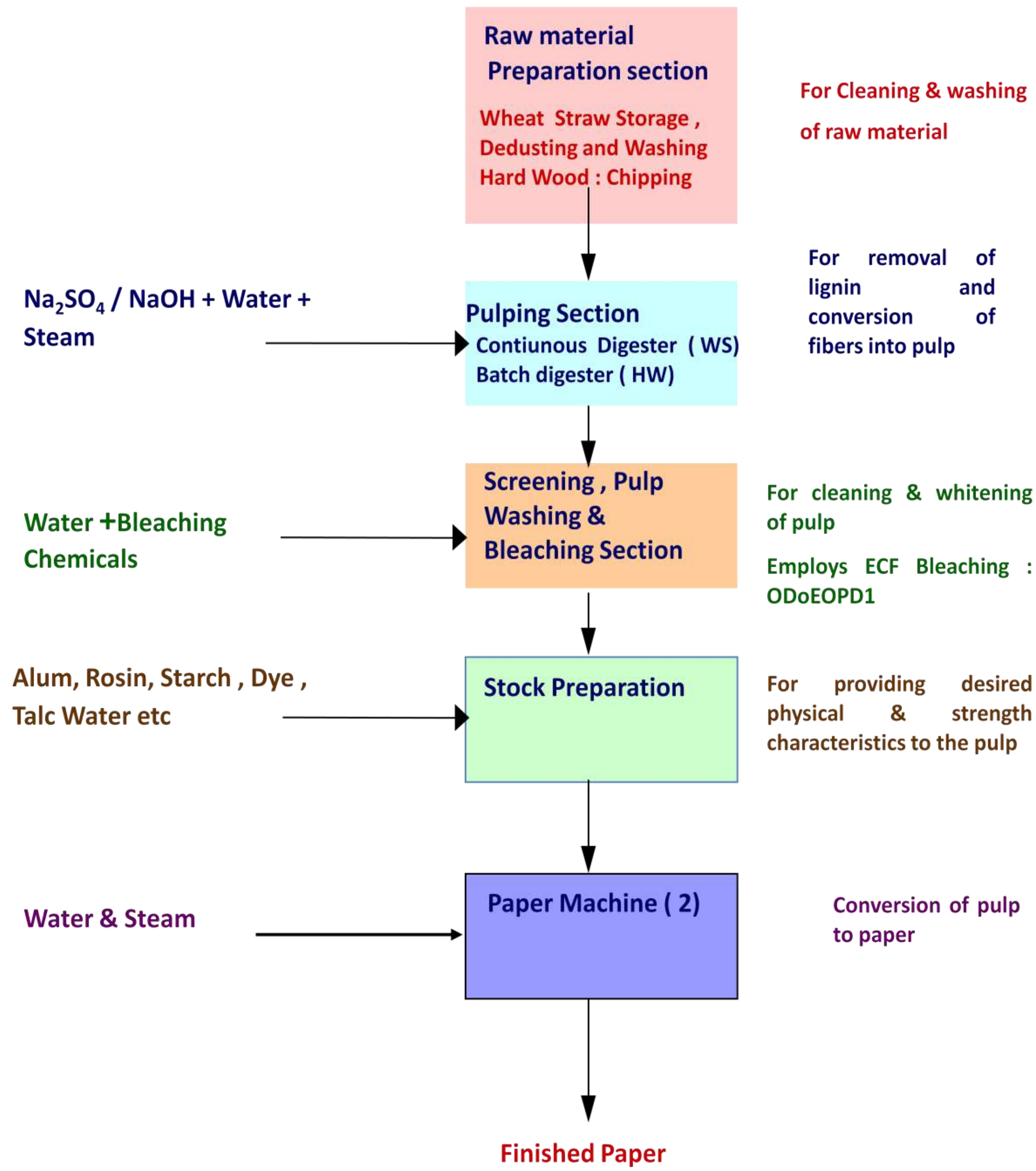

Fig 2.2 (a) General Pulp & Paper Making Process

The general pulp and paper making process of wood and agro & waste residue based pulp and paper mills is similar except for minor differences in process equipments and variables **(Fig 2.2(b))**

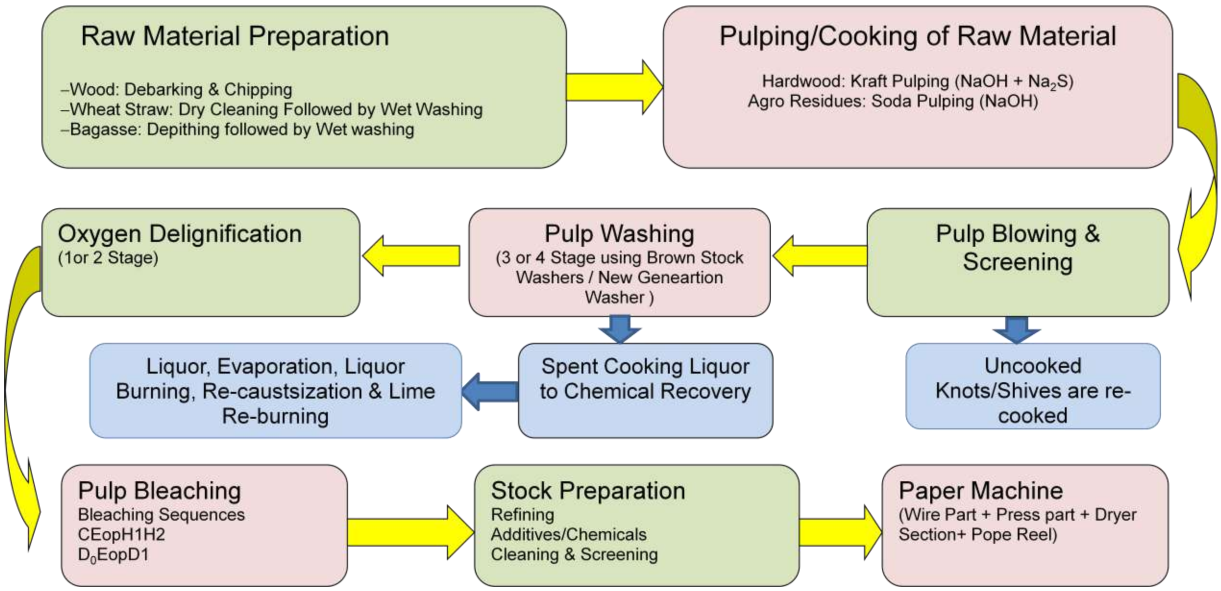

Fig 2.2 (b) Paper Making Process in Wood & Agro Based Paper Mills

A brief summary of the process employed in paper making is summarised in **Annexure –I .**

Chapter 3

FRESH WATER CONSUMPTION - CURRENT STATUS & BENCHMARKS

Water is an integral medium of paper making. From raw material cleaning to manufacture of finished paper water is used for various purpose like raw material / pulp washing , pulp dilution , chemical preparation, pulp transportation , wire and felt cleaning , vacuum pulp sealing , gland cooling , etc. Thus almost all the steps in paper making as indicated in **Fig 3.1** are carried out with use of water or back water / recycled water. Accordingly the pulp and paper industry was considered to be an water intensive industry with water consumption varying between 100 – 250 m^3 / t paper as recent as till 2010 . However, it is to be noted that only 8-10 % of the total fresh water is actually consumed for paper making while the rest is discharged as waste water which is treated in Effluent Treatment Plant so as to meet the discharge norms prior to discharge in any receiving body or reuse / recycle for paper making.

With the introduction of new stringent norms as indicated in **Table -3.1** & **3.2** for Pulp & Paper Industries in Ganga River Basin under **Charter for Water Recycling & Pollution Prevention in Ganga River basin** came a turning point made the pulp and paper mills to optimise their respective fresh water consumption through process modification, technology upgardation and ETP upgaradtion.

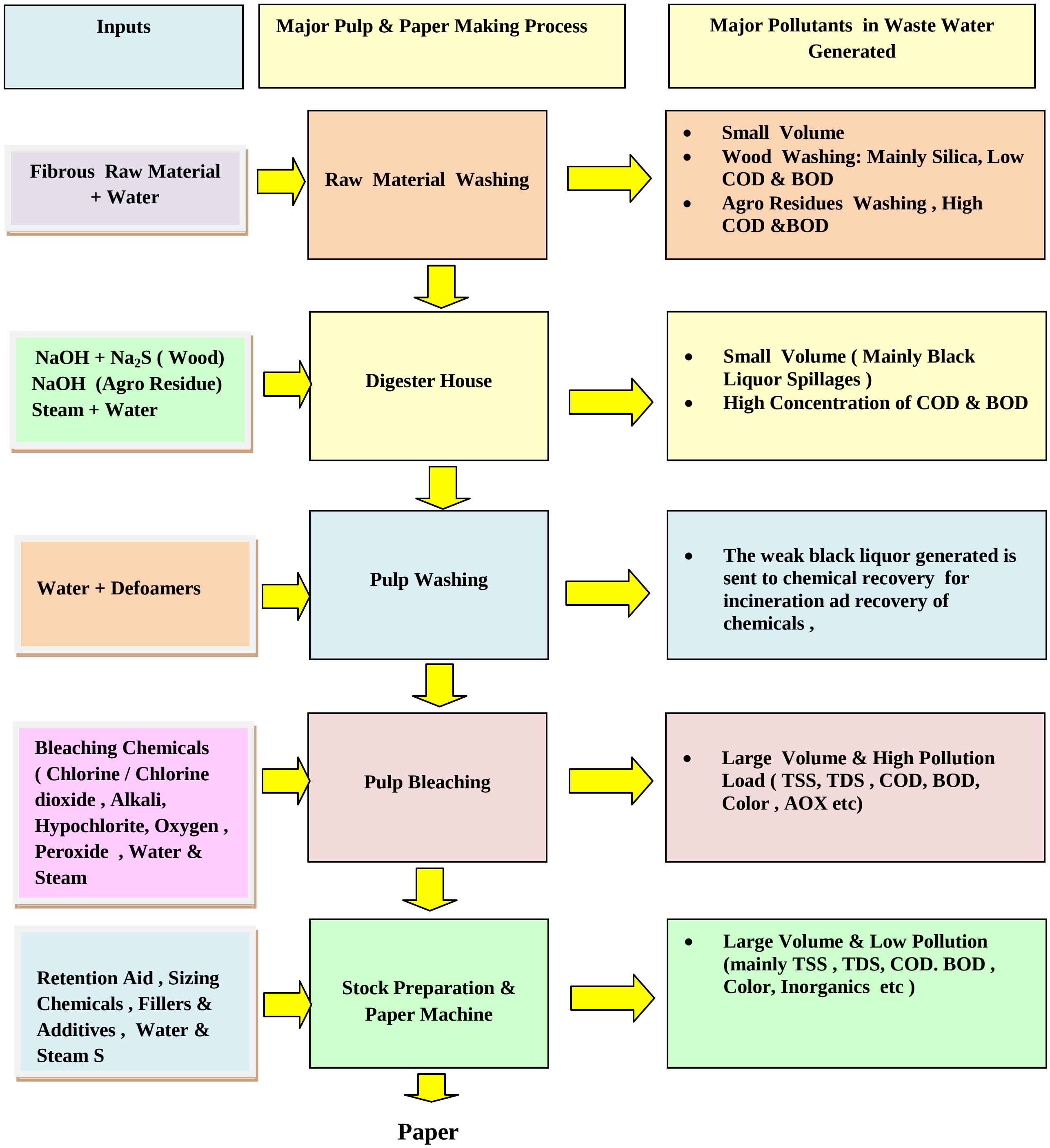

Fig 3.1 Major Water Consuming Process Operations and Sources of Effluent Generation in a Pulp & Paper Mill

Table 3.1 Fresh Water Consumption & Waste Water Discharge Norms under Charter (Likely to be enforced on National Level Soon)

Category	Fresh Water Consumption, $m^3/tone_{paper}$	Waste Water Discharge, $m^3/tone_{paper}$
A1: Wood based – Bleached Grades of Papers, Paperboards & Newsprint	50	40
A1: Wood based -Unbleached Grades of Papers and Paperboards	25	20
B1: Agro based- Bleached Grades of Papers, Paperboards & Newsprint	50	40
B2: Agro based- Unbleached Grades of Papers and Paperboards	25	20
C1: RCF based- Bleached Grades of Papers, Paperboards & Newsprint	15	10
C2: RCF based- Unbleached Grades of Papers and Paperboard	10	6
D: RCF & Market Pulp Based Specialty Paper Mills	50	40

Table 3.2 . Discharge Norms under Charter
(Likely to be enforced on National Level Soon)

Parameter	Unit	Category	
		Integrated Pulp & Paper Mills Producing Chemical Pulp	RCF Based Mills
pH	--	6.5 – 8.5	6.5 – 8.5
Total Suspended Solids (TSS)	mg/l	< 30	< 30
Total Dissolved Solids (TDS)	mg/l	< 1800	< 1600
Chemical Oxygen Demand (COD)	mg/l	< 200	< 150
Biochemical Oxygen Demand (BOD)	mg/l	< 20	< 20
Colour	PCU	< 250	< 150
AOX	mg/l	< 8	-
SAR	--	< 10	< 8

The above norms for wood & agro based pulp and paper mills producing bleached grade of paper were formulated after an intensive brain storming , discussions and estimation of the optimum fresh water requirement in various process opeartions in various categories of mills . For example the optimum fresh water requirement in an agro/ wood based paper mill producing writing and printing grade of paper was estimated as indicated in **Table 3.3**

These estimations were based on the bench marks achieved by the pulp and paper mills in India producing similar grade of papers. As such most of the mills not only in River Ganga Basin but pan India have worked proactively in last few years to reduce their fresh water consumption by 50- 60 % through indigenous strategies as well as process modification and technology upgradation. In the present scenario of average fresh water consumption in different categories of Pulp & Paper Mills is summarized in **Table 3.4 .**

Table 3.3 Optimum Fresh Water Requirement in an Agro / Wood based Paper Mill Producing Writing And Printing Grade of Paper

Unit Processes/Operations	Water Consumption (m3/ t paper)			Waste Water Generation to ETP (m3/ t paper)	Remarks
	Fresh water consumption	Recycled Water Consumption	Total water Consumption		
Raw material Preparation (Wet Washing)	-	20 (Recycled from ETP)	20	15	Required Water Parameters (Treated) – pH – 7 , TSS - < 100 ppm,BOD - < 30 ppm , COD - < 250 ppm,Color - < 1500 Pt. Co units
Pulp Mill					
a.Pulping	-	15+3 (Black Liquor)	18	-	Digester makeup with black liquor / caustic dilution with black liquor Foul condensate (On BSW Washer) Required Water Parameters – TSS - < 25 ppm, Fresh water in High Pressure Shower Required Water Parameters –
b.Pulp washing	3	6 (Foul Condensate from recovery)	9	-	Counter Current washing , pH < 10 , TSS - < 70 ppm, Colour < 500 PCU
c.Pulp bleaching & Washing	10	24 (Paper Machine back water)	34	22	Fresh water at Showers in final stage of bleaching and back water Required Water Parameters- pH ~ 7 TSS -< 100 ppm BOD -< 50 ppm COD -< 250 ppm Color – Perceptible colorless
d. Pulp thickner	2	-	2	-	At Decker Showers
e.Miscellaneous uses including chemical preparation / Gland cooling	5	-	5	-	Required Water Parameters- pH ~ 7 Total Hardness -< 250 ppm
Paper machine + Stock Preparation (Chemical preparation)	11	100 (Uncolored Treated Water)	111	0	Use of self cleaning showers, well maintained pressurized shower, Use of recycled water in low pressure showers, 100% recycling of vacuum pump sealing wastewater, recycling of pump gland cooling Required Water Parameters- pH ~7 TSS -< 10 ppm Total Hardness < 250 ppm Color - Colourless
Chemical Recovery	5	-	5	1	Use of surface Condenser in the multiple effect evaporator replacing barometric leg, recycling pump gland cooling waste water etc. Required Water Parameters- pH ~7 Silica -0.02 ppm Total Hardness -< 250 ppm
Utility	4	-	4	-	Installation of cooling tower to recycle cooling water pumps, compressor, turbines, etc. Required Water Parameters- pH ~7 Silica -0.02 ppm Total Hardness -< 250ppm
Total	40		210	38	

Table 3.4 Fresh Water Consumption in Indian Pulp & Paper Mills

Mill Category	Water Consumption m^3 / t paper
Wood & Agro based Pulp & Paper Mills	**50-60**
RCF Based Writing & Printing Pulp & Paper Mills	**10-15**
RCF Based Kraft Pulp & Paper Mills	**5-10**

The optimum fresh water requirement has been further confirmed through a material and water balance carried out in a mill with installed production capacity of **415 tpd** of writing & printing grade of paper and .having both **straw fiber line** as well as **wood fiber line** to produce writing and printing paper The plant uses a mixed fiber furnish of wheat straw (65%) and hardwood (35%) . Straw Fiber Line (SFL) is having 225 tpd pulp production capacity and Wood based fiberline (WFL) having 125 tpd pulp production capacity . The mill uses **DEopD1** (ECF) bleaching sequence..

The tentative material & water balance of Straw Fibre Line (SFL), Wood Fibre Line (WFL), Chemical Recovery and Cogeneration Power Plant estimated is indicated in **Annexure II .** The assessment is based on pulp consistency maintained in different sections.

From the Water Balance & Material Balance study indicated in Annexure -II , the estimated fresh water consumption in various process operations is summarized in **Table 3.5 .**

Table 3.5 Total Fresh Water Consumption-Section Wise

Sr. No.	Section	Water Consumption, m^3/day
1.	Wet Washing-SFL	632
2.	Pulp Washing-SFL	1778
3.	Pulp Bleaching- SFL	1820
4.	Pulp Washing- WFL	808
5.	Pulp Bleaching-WFL	1010
6.	Paper Machine #1	1739
7.	Paper Machine#2	3080
8.	Chemical Recovery 1 & 2	1450
9.	ClO_2 Plant	642
10.	Cogeneration Power Boilers 2 & 3	4140
11.	ETP & Fire Hydrant	300
12.	Water Losses (Uncountable)	750
	Total Fresh Water Consumption, m^3/day **m^3 / t paper**	**18149** **43.73**

The study results are in close agreement to the reported figures pulp yield, paper production, total water requirement, freshwater consumption, back water usage , effluent generation etc. As indicated the fresh water consumption in an integrated pulp and paper mill with state of art modern fiber line technology in terms of pulping , bleaching , fiber recovery etc is around 40 – 45 m^3 / t paper . The data / information received through questionnaire prepared in context of prepartion of the report , the fresh water consumption in some of the major pulp and paper mills is also indicate similar trends . The fresh water consumption data is summarised in **Table – 3.6**

Table 3.6 : Fresh Water Consumption in Large Wood Based Pulp & Paper Mills

Sections	Fresh Water Consumption, m^3/tone of paper					
	Mill A	**Mill B**	**Mill C**	**Mill D**	**Mill E**	**Mill F**
Raw Material Preparation	15.24	12.95	12.44	Process Wise Data Not Available	24.08	17.31
Pulping						
Pulp Washing						
Pulp Bleaching						
Stock Preparation	13.4	8.85	17.54		15.60	13.19
Paper Machine						
Chemical Recovery	10.15	5.74	11.3		11.0	10.20
Boiler/Power House						
Glands Cooling & Vacuum Pump Sealing	--	--	3.5		--	13.91
Cooling Tower	4.85	--	--		4.6	
Miscellaneous	4.38	1.75	0		--	--
Fresh water Consumption, m^3/tpaper	**48.02**	**29.29***	**46.68**	**40 - 48**	**55.28**	**54**

Mill A : *Wood Based ,* ***Mill B :*** *Wood + Purchase Pulp* ***, Mill C :*** *Wood Based* ***, Mill D:*** *Wood + Agro* ***based , Mill E : Wood + RCF + Imported Pulp based***

****The mill is using purchased pulp***

As indicated the general fresh water consumtion by wood based pulp and paper mills is around 45- 55 m^3 / t paper . The fresh water consumption in the pulp and paper mills depends upon

- Type of Raw material used
- Quality of End product
- Level of Technology & Equipment
- Extent of Reuse / recycling Practices
- Water Avaialability

The optimisation of fresh water consumption through reuse / recycle depends upon the water quality tolearnce parameters .

In all , the adoption of in-house approach / best practices & new technologies have translated into significant reduction in fresh water consumption through optimum water consumption, improved back water and treated effluent quality making increased reuse / recycling feasible . The range of reduction of fresh water consumption achieved by the mills through adoption of process wise appropriate strategies / technologies is summarized in **Table 3.7**

Table 3.7 Best Practices Adopted by Mill for Reduction in Fresh Water Consumption

Section	**Water Consumption , m^3 / t_{paper}**	
	Best Practices	**Fresh Water Reduction, m^3 / ton_{paper}**
Raw Material Preparation (Agro Residues)	– Installation of separate clarifier for wet washings and 100 % reuse of overflow – Use of Treated Water/Black Liquor Foul Condensate as make up water to wet washings	5 - 10
Pulp Washing	– Use of Oxygen Delignification (ODL) Back Water in BSW shower – Use of High Consistency Washers/Presses	3 - 4
Pulp Bleaching	– Use of Oxygen Delignification (ODL) – Use of Elemental Chlorine Free	15 - 18

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	Bleaching – Use of High Consistency Washers/ Presses	
Paper Machine Showers	– Reduction in nozzle size of showers – Installation of Poly Disc Filter (PDF) for treatment of back water so as to reuse it in paper machine LP showers	12 - 16
Sealing & Cooling	– Installation of Cooling Tower followed by micro filtration for making it suitable for reuse	5 – 7
Boiler Make Up Water	– Increase in steam condensate recovery	3 – 4
Chemical Recovery	– Use of black liquor secondary condensate in mud washing and thickening	5 - 10
Miscellaneous	– Spillage Control etc.	3 - 5
Total Reduction in Fresh water Consumption, m^3 / ton $_{paper}$		**51 - 74**

A comparative fresh water savings adoption of best practices compared to conventional practices adopted in pulp and paper making is indicated in **Table 3.8**

Table 3.8 Section Wise Fresh Water Consumption In Wood/Agro Based Integrated Paper Mills:

Section	**Water Consumption, m^3 / t_{paper}**	
	With Conventional Practices	**With Best Practices**
Raw Material Preparation (Agro Residues)	**5 – 10**	**Nil**
Cooking	**Nil**	**Nil**
Pulp Washing	**8 – 10**	**5 - 6**
Pulp Bleaching	**25 – 30**	**10 - 12**
Chemical Preparation	**2 – 5**	**2 - 5**
Paper Machine Showers	**30 – 40**	**18 - 24**
Sealing & Cooling	**10 – 15**	**5 – 8**
Boiler Make Up Water	**6 – 8**	**3 – 4**
Chemical Recovery	**5 – 10**	**Nil**
Spillage etc. to ETP	**3 – 5**	**Nil**
Total	**94 - 133**	**43 - 59**

The cost of the technological interventions for reducing the fresh water consumption / waste water discharge or facilitate reuse / recycled of back water / treated effluent is indicated in **Table 3.9.**

Table 3.9 Cost of Technologies adopted by Pulp & Paper Mills for Water Conservation

Technology Implemented	Capacity, TPD	Capital Investment INR Million
Continuous Digester	**200- 400**	**750 – 1500**
New Generation Pulp Washing System with Twin Roll Press	**250- 450**	**1000- 2000**
Oxygen Delignification (ODL)	**150 - 450**	**300**
New Generation Pulp Bleaching System with Twin Roll Press	**250- 450**	**1000- 2000**
Poly Disc Filter at Paper Machine	**1500 - 3000 m^3/day (white water) and 3- 6 TPD fibre recovery**	**500- 100**
Conventional Chemical Recovery System	**400- 6000 BLDS /day**	**1000- 2000**
UASB Reactor	**20000 - 5000 m^3 /day**	**50- 100**

The Return on Investment (RoI) on above technologies as well as operational cost vary from mill to mill and also depends on scale of production, raw material used and grades of paper produced. As discussed with various pulp and paper mills, in general the payback varies from 3- 7 years for these technologies in context of direct or indirect savings involving energy conservation, recovery of paper making fiber, water conservation, recovery of chemicals, recovery of biogas , reduced chemical & energy consumption in ETP etc.

Zero Liquid Discharge (ZLD) Concept, Evolution and Technology Options

Chapter 4

4 .1 About Zero Liquid Discharge

The conventional **'Physico-Chemical-Biological'** treatment in various industrial sector including pulp and paper mills does not remove TDS , color , soluble COD, BOD etc completely in the treated effluent thus limiting its reuse / recycle back into the process.

Zero Liquid Discharge (ZLD) is a system consisting of unit processes or unit operations or their combination, such that there is no discharge of liquid effluent from an industry, process plant, etc. ZLD status of a unit is a reflection of the fact that the effluent generated is effectively treated, recycled and reused by the mill / unit and no liquid is discharge outside its premises. Zero liquid discharge is generally accomplished by concentrating the wastewater through various technologies together with membrane-based and multi effect evaporation-based systems. The main aim of ZLD is to recover useful products and salts from rejects, apart from recovery of maximum water for recycle. A ZLD system involves a range of advanced wastewater treatment technologies aimed at improving water usage efficiency and resource recovery through recycle, recovery and re-use of the 'treated' wastewater and thereby ensure there is no discharge of wastewater to the environment. Major ZLD Technologies are as follows:

- **Solvent extraction/Stripper**
- **Membrane Bio-Reactor Technology (MBR)**
- **Ultra-filtration/Reverse Osmosis**
- **Evaporation Technologies**
- **Agitated Thin Film Dryer (ATFD)**
- **Incinerator**

The various ZLD technologies, thir respective merits and limitation of above technologies is summarized in **Table 4.1.**

Table 4.1 Available ZLD Technologies / Options - Merits & Limitation

ZLD Technology	Application	Merits	Limitation	Application
Membrane Bio Reactor (MBR)	Used as biological secondary treatment for reduction of organic load.	Secondary clarifier not required.	Capital cost is more than other aerobic biological technologies (ASP, SBR, MBBR).	Textile Industry
		Treated water quality is better than conventional ASP, MBBR and SBR.	Membrane replacement after five years.	CETPs
		Post treatment of sand filtration not required.		Oil Refineries
				Fertilizer Industry
Solvent recovery – Air Stripper	Used for recovering solvents/ammonia recovery by providing air.	Conventional proven method for removal of solvents.	Applicable only when large quantity of solvent with low solubility in water is present in wastewater.	Recovery of useful solvents, ammonia in pharmaceutical industry
		Economical when solvents with low solubility in water are present in wastewater.	Difficult to capture solvent when in low concentration.	Pesticide Industry
				Chemical Industry
Solvent Recovery – Steam Stripper	Used for recovering solvents by using steam.	Solvent recovery is more compared to air stripping.	Not suitable for water miscible, high boiling solvents.	Recovery of useful solvents, ammonia in pharmaceutical industry
	Solvents can be reused or are saleable.	Useful even less quantity of solvent present in wastewater	Scaling occurs in column which is to be cleaned periodically.	Pesticide Industry
				Chemical Industry
Ultra Filtration (UF)	Used for removal of colloidal matter and bacteria and viruses.	Removes suspended, colloidal particles, bacteria, viruses.	Does not filter dissolved solids, gases and organics. Frequent backwash, membrane cleaning.	Pre-treatment to RO in all ZLD plants.
	Used as pre-treatment to RO.	Best pre-treatment for RO.	Replacement of membranes after 5 years required.	
Reverse Osmosis (RO)	Used for removal of salinity (TDS) and residual organics by passing wastewater through semi-permeable membrane by	Most effective treatment for removal of salinity (TDS) with more than 99% salt rejection.	Very high capital cost.	Used in all industrial sectors for TDS removal and recycling the water.
		Clean technology and no handling of chemicals like acid/alkali like ion exchange technology.	High energy consumption due to high pressure pumps.	
		Permeate water is free of	Membrane replacement	

	applying high pressure.	ions and can be used in industrial processes.	required after application of 3 years. Cleaning of membrane frequently due to membrane fouling Reject Water	
Multiple Effect Evaporator (MEE)	Used to evaporate wastewater to separate water and salt by using heat of steam in sequence of vessels.	Proven method for recovery of water from saline water and separation of salt.	Very high operating cost due to steam requirement.	Pharmaceutical Industry, Textile Industry, Pesticide Industry, Dyes and Dye Intermediates, Steel Industry, Fertilizer Industry
Mechanical Vacuum Compressor (MVR)	Water vapour generated in the evaporator is compressed to higher pressure which acts as heat source for evaporation.	Eliminates thermal energy requirement. Useful when steam not available. Low operating cost.	Suitable only for liquid with narrow boiling point rise (BPR). Suitable when ready steam is not available in the industry.	Textile Industry
Crystallizer	Used to dry high TDS water or products using heat.	Used for recovery of salts like Sodium Sulphate, Sodium Chloride, Sodium Thiosulphate, Zinc Sulphate etc. Simple Evaporation method of single effect evaporation.	Scaling and corrosion of unit is a problem. Requires frequent cleaning.	All industrial sectors.
Agitated Thin Film Dryer (ATFD)	Used to dry high TDS water or products using fast revolving rotor in a heating jacket.	Good heat conductivity so can be applied for highly viscous fluids. Gentle evaporation and high evaporation rate. Continuous cleaning of heating surface. One passes Evaporation.	Scaling and corrosion of unit is a problem.	Application in salt recovery in Dye and Dye Intermediates Textile Industry Pharmaceutical Industry for final drying before disposal.
Incinerator	Used for burning the concentrated effluent by thermal energy	Useful method for very high strength (High COD) effluent which is difficult to biodegrade. No further treatment is required.	Requires very high energy. Operational cost is high. Capital cost is high. Viable for only small quantities of effluent.	Pharmaceutical Industry Dye and Dye Intermediates Pesticide Industry

The major factors influencing the selection of appropriate ZLD system, are :

- **TDS (Total Dissolved Solids) level in effluent**
- **Organic Matter in the effluent i.e. BOD (Biochemical Oxygen Demand) and COD (Chemical Oxygen Demand)**
- **Hardness in the effluent**
- **Size of Particle in the effluent**
- **Color of the effluent**

In paper industry perspective inspite of operating on zero liquid discharge still a pulp and paper mill will require 2- 3 m^3 / t paper as make up water due to steam, evaporation losses , and loss of water as moisture along with finished paper , sludge etc . A typical ZLD system incorporates following stages :

- **Pre-treatment**
- **Membrane Filtration (Ultra / Nano Filtration / Reverse Osmosis)**
- **Evaporatoration & Crystallization**

4.2 Historical Perspective

ZLD technology was initially developed for power plants, in USA and later implemented globally. During early seventies, high salinity of the River Colorado due to discharge from power plants, developed the need for imposing Zero Liquid Discharge. Regulators were primarily concerned with discharge from scrubbers and cooling tower blow downs in power plants. First ZLD installed was of 114-454m^3/hour capacity , based on evaporation/crystallization. Initially low-cost ponds were used for evaporation of Reverse Osmosis (RO) reject. In Germany, ZLD systems for coal-fired power plants were a result of strict regulations and laws in the 1980s.

4.3 Challenges of ZLD

Although ZLD systems are capable of minimizing contamination of water sources and facilitate water reuse / recycle , its industrial scale applications are restricted due to their several challenges / limitations which restrict its wide spread acceptance and implementation of ZLD such as :

- Development of indigenous and cost effective ZLD systems applicable to various scale of operations.
- Disposal of sludge / hazardous solid wastes generated
- High CAPEX & OPEX laeding to increase in treatment cost and over all production cost thus impacting competitiveness and sustainability of the industry
- Frequent fouling of membranes and cost of membranes
- Energy intensive leading to high carbon foot print
- Custom-design on case-to-case basis

4.4 Major Drivers for ZLD

In recent times , with depletion of ground water level in some regions of the country , less availability of surface water and impact on receiving stream due to less flow the pulp and paper mills having been facing increasing pressure from regulatory authorities to reduce their fresh water consumption and consequently waste water discharge. The industry has been overall proactive and has significantly reduced fresh water consumption by over 50- 60 % in last 5-6 years. However the regulatory regime in various states at time of consent for operation renewal, are now demanding fixed time frame or time line to achieve ZLD.

In recent times , some RCF based paper mills producing low quality grade of kraft paper have switched over to ZLD without any major technology intervention but it has more for saving ETP operation cost and escaping environmental non compliance issue rather than water conservation. Reusing &

Recycling of Treated effluent without technology intervention leads to various issues as summarized as under :

Impact of Dissolved Colloidal Substances (DCS) Build up	❑ **Poor washing.** ❑ **Foaming problem (due to build up of wood resin) which leads to :** • **loss in vacuum ,** • **poor drainage ,** • **poor web formation** • **over use of defoamers which lead to deposit problem** ❑ **Fatty acids and resin acids from virgin fibers with hydrolysed sizing agents form pitch** ❑ **Problems of Scales (carbonates and silicates)** ❑ **Corrosion (sulfates, chlorides, iron and aluminum ions)** ❑ **Brightness reversion (due to Fe^{2+})** ❑ **Bacterial growth due to higher dissolved organics** ❑ **Odour problem in paper** ❑ **High BOD and color in effluent**
Impact of Temperature Increase	**Temperature increase in the closed loop / circuit may lead to :** ❑ **Accumulation of pitch on machine fabric or press felt leading to negative impact on paper making process and quality** ❑ **Create corrosive conditions in presence of high concentration of chlorides and sulphates** ❑ **Promote Bacterial growth which may impact**

	• **Paper Quality** • **Increase demand of retention aids (due to increase in VFA)**
Impact of TSS build up	❑ **Plugging of shower nozzles, small lines and felts** ❑ **Deposit formation (biological . Non biological) and Intensification of biological slime** ❑ **Lower filtration capacity of fiber recovery units.**
Increase in Anionic Trash and other materials	❑ **Increase the demand of wet end chemicals added to increase the retention of fibers** ❑ **Use of waste paper introduces adhesives , residues , tapes, hydrolyzing sizing agents which in a water system produce particulate component that tend to stick to paper machine parts and final product causing many problems**
Other Impacts	❑ **Low life of paper machine felt and wire** ❑ **Increased bleaching chemical consumption** ❑ **Increase in broke** ❑ **Inorganic fouling in process equipments in different unit operations frequently cause** – **Reduced stock / liquor flow reducing process efficiency** – **Downtime to clean the fouling causing production downtime** – **Quality defects in end products (pulp, paper etc)**

Thus the build up of organic and inorganic load due to system closure has adverse impact on process operations and product quality, To address these limitation the industry require appropriate technological intervention these include :

The conventional ZLD system is based on evaporation and crystallization operations. Evaporation usually aims at **>**90% water recovery while crystallization may achieve 100% recovery . However operational and capital costs is still very high due to high energy consumption (@ 20-40 kWh/m^3) , use of chemicals and expensive corrosion-resistant materials.

The other option is internal purification through kidney technologies like microfiltration , ultra filtration, nano filtration and reverse osmosis is required to successfully implement ZLD / Closed circuit system

4.5 Technological Options for ZLD

Due to increase in organic and inorganic load during recycling and consequently is impact on process operations and product quality, internal purification through **membrane filtration i.e microfiltartion , ultra filtration, nano filtration and reverse osmosis** is an integral part of ZLD system / Closed circuit system

The membrane filtration is a unit separation procedure based on pressure differential across the thickness of the membrane (trans membrane pressure) and includes :

Microfiltration

A microfiltration filter has a pore size around 0.1 micron, so when water undergoes microfiltration, many microorganisms are removed, but viruses remain in the water.

Ultrafiltration

An ultrafiltration filter has a pore size around 0.01 micron. Ultrafiltration would remove these larger particles, and may remove some viruses.

Nanofiltration

- Intermediate between Ultra Filtration & Reverse Osmosis
- A nanofiltration filter has a pore size around 0.001 micron. Nanofiltration removes most organic molecules, nearly all viruses, most of the natural organic matter and a range of salts.
- Nanofiltration allows monovalent ions to pass while rejects high % of divalent and multivalent ions (which make water hard) so nanofiltration is often used to soften hard water.

Reverse Osmosis

- Reverse osmosis filters have finest membrane size (pore size around 0.0001 micron.) In Reverse osmosis pressure is applied to reverse the natural flow of water . This forces the water to move from the more concentrated solution to the weakerThus the contaminants end up on one side of semi permeable membrane and pure water on the other side Reverse osmosis removes turbidity , microbes and virtually all dissolved substances RO allows only pure water through the membrane filtering out salts and other organics. In addition to removing all organic molecules and viruses, reverse osmosis also removes most minerals that are present in the water (desalinates the water)

  Fig 4.1 (a) & (b) indicates the capability of various membrane filtration systems in removing various pollution load

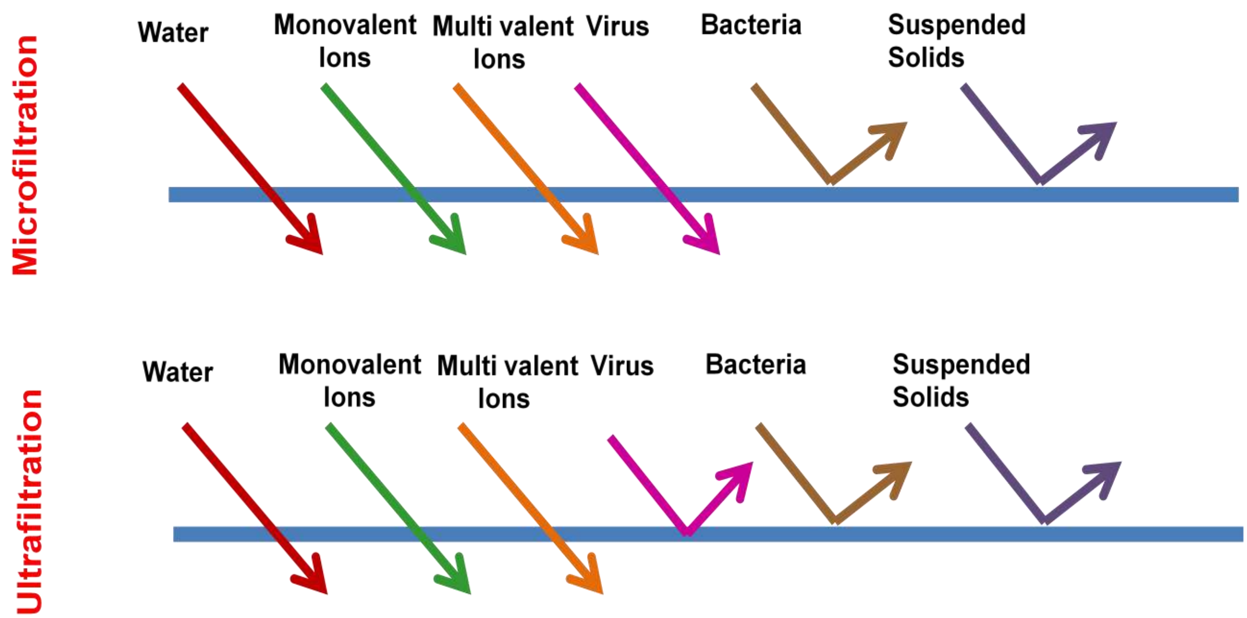


Fig 4.1 (a) Microfiltration & Ultra filtration Treatrment Efficiency

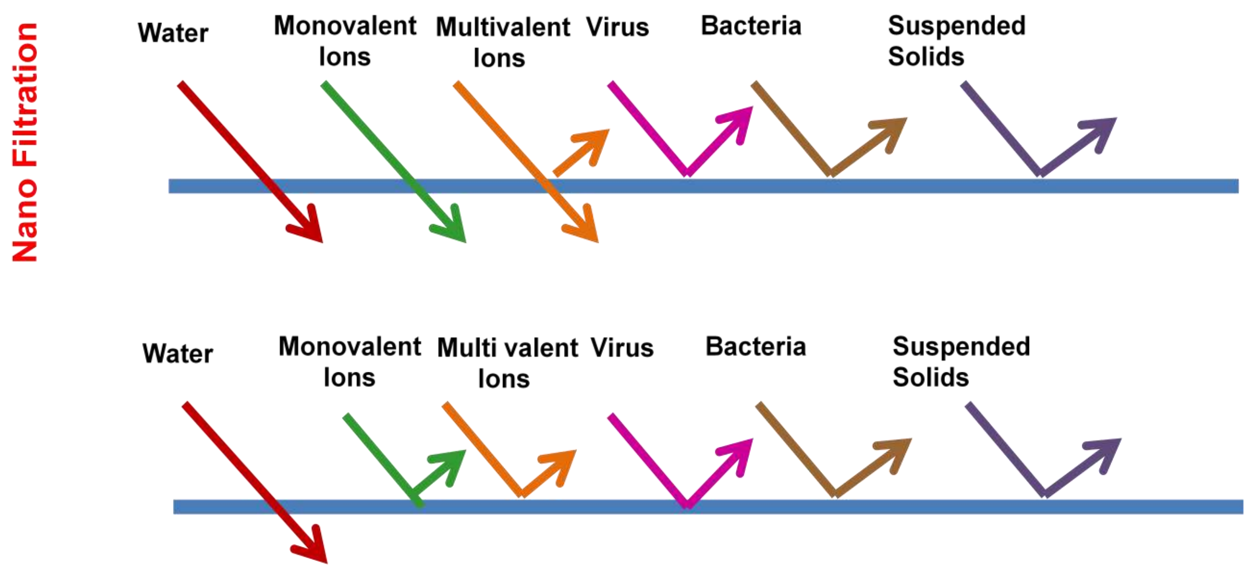


Fig 4.1 (b) Nano filtration & Reverse Osmosis Treatrment Efficiency

Factors Influencing Performance of Membrane Systems

- **Membrane Pore Size**
- **Membrane Pore Distribution**

- **Particle Charge**
- **Particle Size**
- **Charge of Membrane**
- **Hydrostatic Force**

Smaller the pore size , smaller the size of particles that can pass through membranes As the pore get smaller system becomes more costly to operate. Indicated above the order of membrane with respect to increasing relative pore size is:

Microfiltration > **Ultrafiltration > Nano Filtration > Reverse Osmosis**

While the **membrane filtration** comprising of **Micro filtration , Ultrafiltration , Nano Filtration & Reverse Osmosis individual or in combination** as per requirement is an integral part of ZLD System for treatment of effluent to recover water of process water quality . For the handling / treatment of the rejects there are commonly two routes

- **Evaporation & Crystallization**
- **Evaporation & AFTD**

Evaporation & Crystallization

Evaporation

Evaporators include a heat exchanger to boil the solution along with a system to separate the vapor from the boiling solution. Normally evaporators operate at reduced pressure so that the boiling point (BP) is reduced. As a result vacuum pump or a jet ejector vacuum system on the last effect of the evaporator is required. The evaporaters are available in various configurations like Horizontal-tube, Vertical tube, Long tube vertical and Forced circulation. The Selection of appropriate evaporator depends upon -

- Feed Solution viscosity (and its increase during evaporation)
- Nature of the product and the solvent (e.g. heat sensitivity and corrosiveness)

- Fouling characteristics
- Foaming characteristics

The general layout of the Evaporater System is indicated in **Fig 4.2**

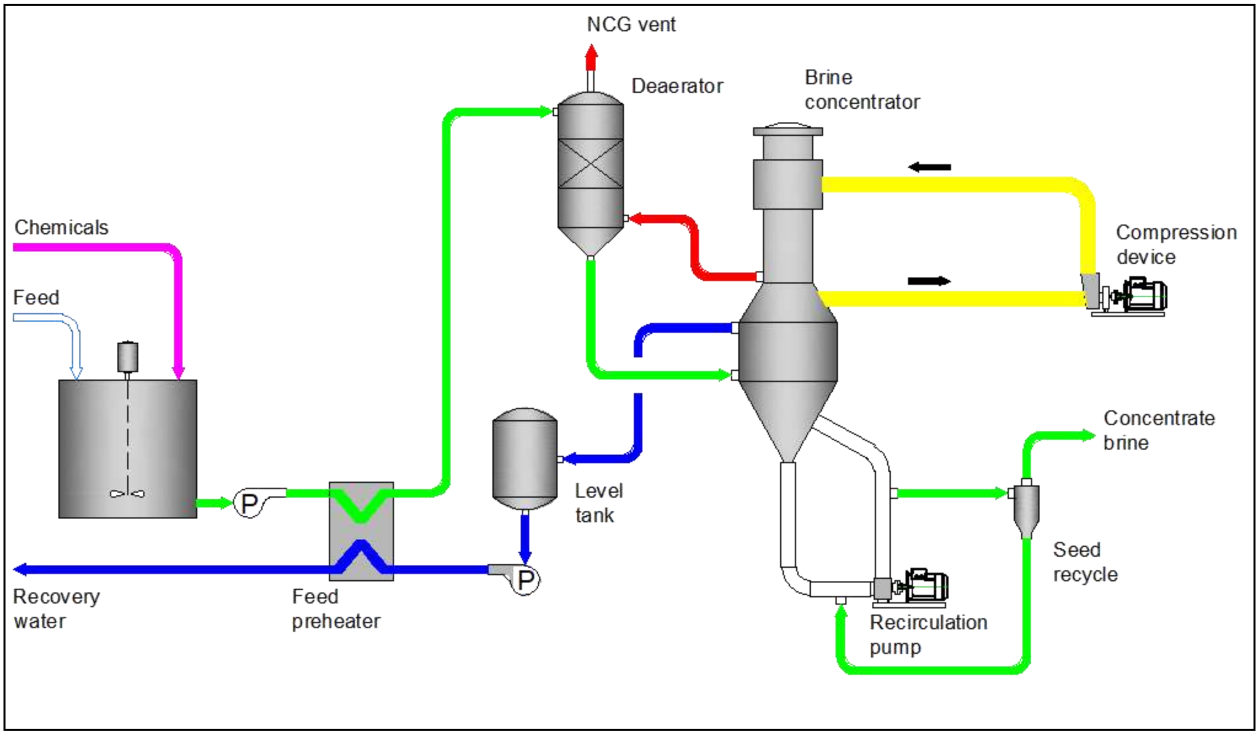


Fig 4.2 Layout of the Evaporator

Mechanical Vapour Compression Technology

In the MVC evaporator, heat is transferred to the circulating stream by condensing vapor from the compressor(s) (increasing the vapor's temperature and pressure). In doing so it requires much less energy than a conventional evaporator.

During process **(Fig.4.3),** the vapor generated from the circulating stream has a large amount of energy in the form of latent heat at a temperature of the boiling wastewater. In order for the main heat exchanger to work, a higher temperature will be required. In order to get to the needed higher temperature, the vapor is compressed by the vapor compressor. Compressing the vapor raises its pressure (thus its saturation temperature as well) and produces the needed heat transfer in the main heat exchanger allowing for recycling the energy contained by the vapor, greatly improving the total energy efficiency

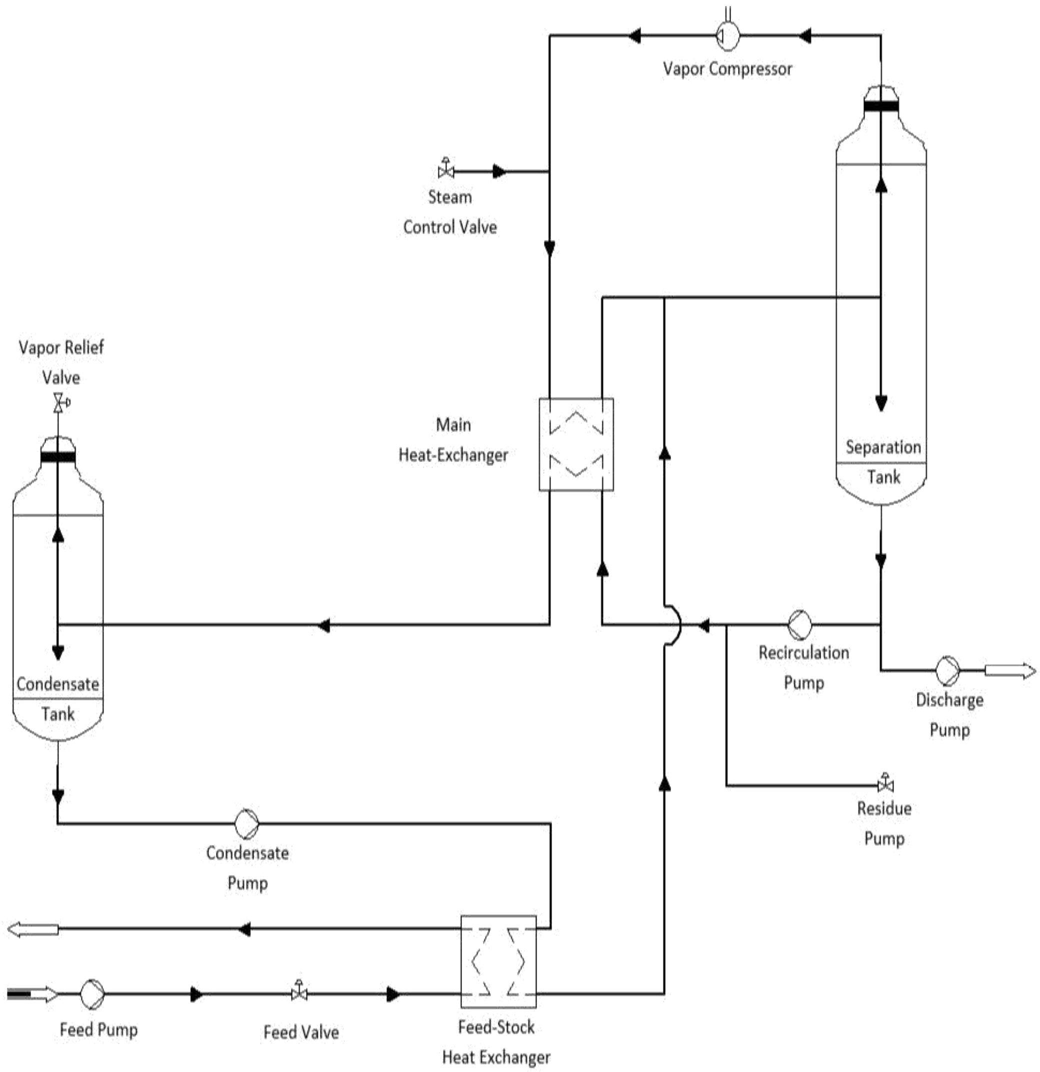


Fig.4.3 Mechanical Vapor Compression process

Crystallization

Crystallization is the production of a solid (crystal or precipitate) formed from a homogeneous, liquid which is concentrated to supersaturation levels (concentration > solubility) at that temperature**.(Fig 4.4)**

The available crystallization processes include :

1. Supersaturation by cooling the solution with trivial evaporation

2. Supersaturation by evaporation of the solvent with little cooling
3. Evaporation by a combination of cooling and evaporation in adiabatic evaporators (vacuum crystallizers)

Crystallizers can put up with the continuous crystallization of all sparingly and highly soluble sodium salts such as sodium chloride and sodium sulfate, without excessive scaling and cleaning frequencies. However the process involves high specific energy consumption (OPEX) and higher capital cost (CAPEX).

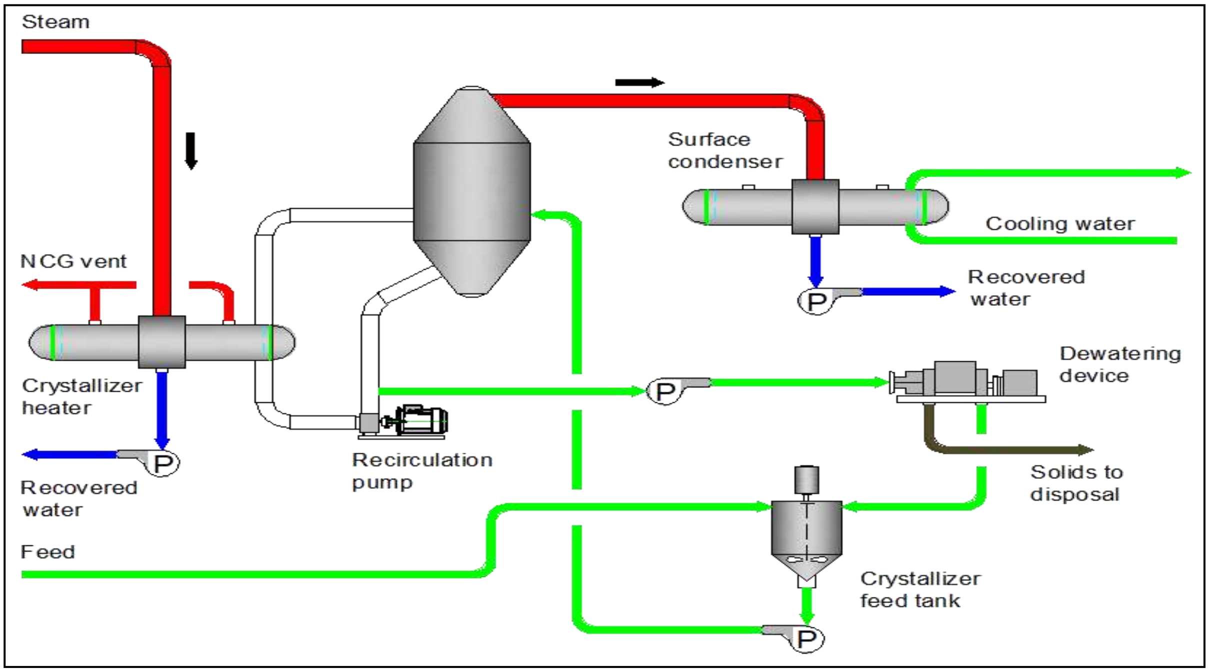


Fig 4.4 Crystallization Process for ZLD

Recently an agro based pulp and paper mill has initiated a ZLD system comprising of **Membrane Technology, Mechanical Vapor Recompressor (MVR)** for reject handing **Membrane System** and **Agitated Thin Film Dryer (ATFD)** for sludge handling of MVR system. **(Fig 4.5)**

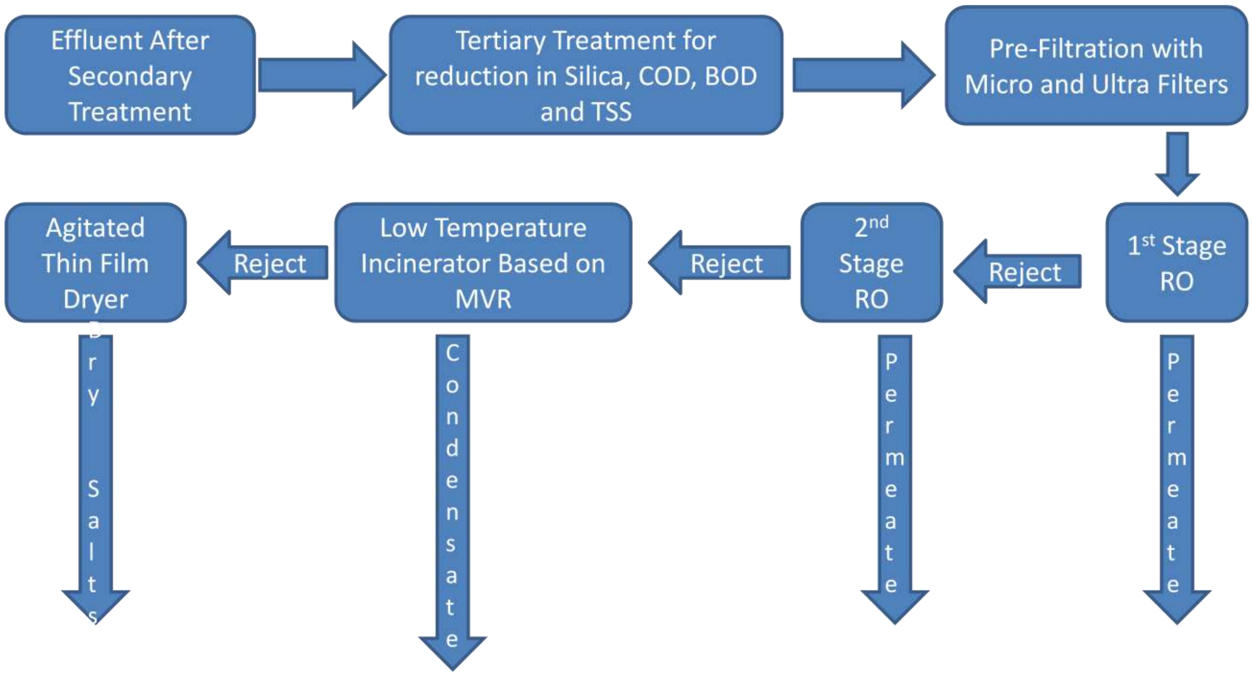


Fig 4.5 ZLD System based on Membrane Filtration , MVR & AFTD

The reusable water recovery (TDS < 100 ppm) from the complete system is reported to be around 98%. However

TECHNO-ECONOMIC FEASIBILITY OF ZLD – INDIAN PAPER INDUSTRY PERSPECTIVE

Chapter 5

The techno –economic feasibility of ZLD is dependent on various factors namely :

- Technological options Used
- Volume of effluent to be treated
- No of Stages Used
- Cost of Water

Techno –economic feasibility of a proposed ZLD system involving **Flash Mixer, DAF followed by Clarifier and subsequently combination of Ultra Filtration , Nano Filtration and Reverse Osmosis, Evaporation and Crystallization** in Indian Paper Industry perspective is discussed as under :

This is a theoretical case study based on inputs from technology suppliers and Pulp & Paper mills. The **ZLD System involving Ultra Filtration , Nano Filtartion, Reverse Osmosis, Evaporator & Concentrator , Crystallsiation / Centrifuge** is indicated in **Fig 5.1**

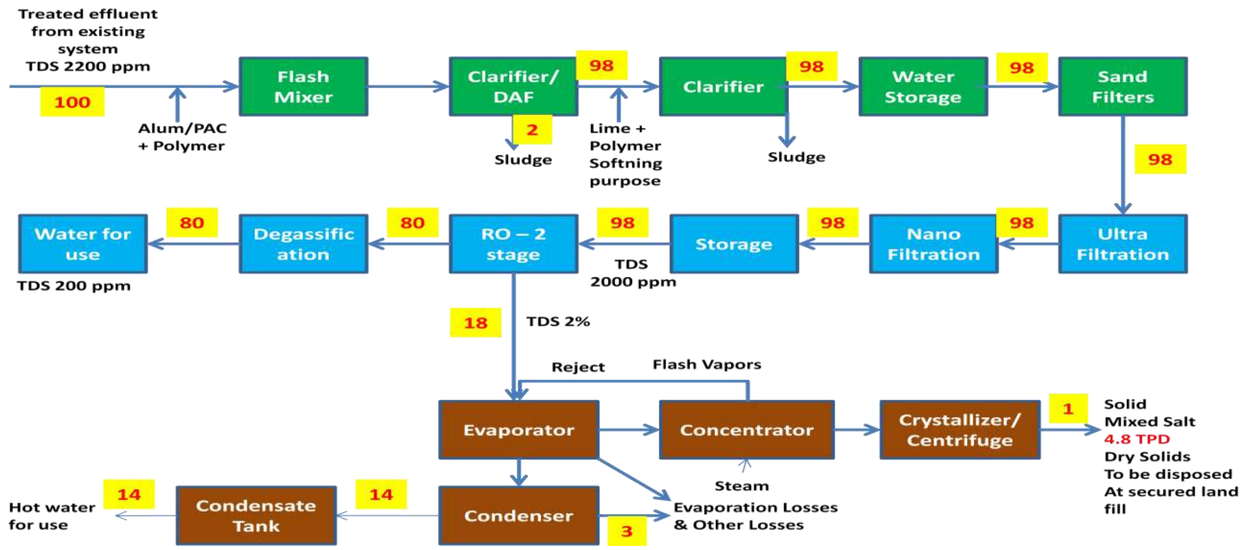


Fig 5.1 ZLD System involving Ultra Filtration , Nano Filtartion , Reverse Osmosis, Evaporator & Concentrator , Crystallsiation / Centrifuge

The investment and operative cost of ZLD system based on RO for a pulp and paper mill in terms of volume of effluent as well as for production capacity 100 , 250 & 500 tpd is summarized in **Table 5.1 & Table 5.2 :**

Table 5.1 Estimated Cost of Treatment for 100 m^3/hr Treated Effluent

Particulars	UoM	Value	Remarks
a. Effluent Volume	m^3/hr	100	
b. RO Treatment Output	m^3/hr	80	
c. RO Reject	m^3/hr	20	
d. RO TDS	%	2	
e. Capital Cost			
f. RO Plant for 100 m^3/hr capacity	Rs in Crore	5	
g. Evaporator, Crystallizer & Centrifuge	Rs in Crore	19	
	Rs in Crore	24*	**Excluding Clarifier, mixers, pumping, pipelines, civil work etc.**
Operational Cost			
h. Reverse Osmosis (RO) Pretreatment	Rs/m^3	**10**	**Includes Chemicals / Sludge filtration (Lime, Polymer, PAC filtration, Power consumption)**
i. RO Operation	Rs/m^3	**30.24**	**Operation Cost**

			includes **Chemicals and Power cost ~ Rs 25 / m^3** **Membrane cost Rs 5.24 / m^3 #**
j. Evaporator, Crystallizer & Centrifuge	Rs/m^3		
k. Steam MP @ 3.5TPH, Rs 2000/T Steam Cost	Rs/m^3	350.00	Tentative figures as shared by technology suppliers
l. Power Cost 340 kWh @ Rs 7.5/kWh (Condensing power)	Rs/m^3	127.50	
m. Total cost for 20 m^3/hr RO reject up to crystallization	Rs/m^3	477.5	
n. Total cost for 20m^3/hr RO reject up to crystallization at base level of 100 m^3/hr		**95.5**	
o. Total Cost including ETP operations, Pretreatment, RO & Evaporation and Crystallization, the expected cost of effluent treatment	**Rs/m^3**	**135.74**	**Total cost excludes sludge handling and disposal, maintenance , operation, manpower etc.**

Table 5.1 Estimated Cost of Treatment for Mill capacity 100, 250 & 500 tpd

Particulars	**UoM**	**Case 1**	**Case 2**	**Case 3**
Mill Capacity	**TPD**	**100**	**250**	**500**
I. Effluent Volume !	**m^3/day**	**4000**	**10000**	**20000**
II. Factor		1.67	4.17	8.33
III. Expected Capital Cost	Rs in Crores/ annum	60	120	240
IV . Expected Operating Cost	Rs in Crores/annum	19.82	49.55	99.09
V. Operating Cost	Rs/MT	5429.6	5429.6	5429.6
VI. Expected Solid wastes generation, BD basis	TPD	8	20	40
VII . Expected Solid wastes generation, @50% dry basis	TPD	16.0	40.0	80.0
VIII. Expected additiona mixed salts Solid wastes generated	TPA	5600	14000	28000

IX . Expected additiona mixed salts Solid wastes generated in 10 years	T	56000	140000	280000
X. Tentative area for landfil disposal*	sqm/t of solid wastes generated in 10 years	8848	22120	44240
XI. Total area required for next 10 years	Ha	0.88	2.21	4.42
XII. Secured landfill preparation considering 10 years of operations **	Rs Cr	5.31	13.27	26.54
XIII . Cost per year for solid waste disposal - SLF	Rs Cr / annum	0.53	1.33	2.65
XIV .Sludge transportation cost ***	Rs /annum	1120000	2800000	5600000
XV. Total cost per annum for Solid waste handling and disposal	Rs in Cr / annum	0.643	1.607	3.214
XVI. Cost per m^3 of effluent treated	**Rs/ m^3**	**4.59**	**4.59**	**4.59**
XVII. Cost per Ton of paper	**Rs/m^3**	**183.7**	**183.7**	**183.7**
XVIII. Manpower Cost for running RO, Evaporator, Crystallizer, Centrifuge, secured landfill etc	**Rs/annum**	**32.5 ø**	**53 øø**	**85.5 øøø**
XIX . Cost per m^3 effluent	**Rs/m^3**	**2.3**	**1.5**	**1.2**
XX. Maintenance & Consumables				
XXI. Chemicals for ZLD Evaporation & Crystallization plant				
XXII . Caustic Requirement	MT/month	2.5	6.25	15.625
XXIII Nitric acid Requirement	MT/month	1.2	3.0	7.5
XXIV Caustic Requirement, @ Rs 45000/T	Rs/Month	87500	281250	703125
XXV . Nitric acid Requirementc @ Rs 35000 /T	Rs/Month	54000	105000	262500
XXVIOther Consumables (Enginnering / Others)	Rs/Month	100000	200000	400000
XXVIITotal		241500	586250	1365625
XXVII Total Rs annum		2898000	7035000	16387500
XXVIII Total cost per m^3	**Rs/m^3**	**2.07**	**2.01**	**2.34**
XXIX Total Operating Cost, Rs/ m^3 **h + i+ n + XVI +XIX+ XXVIII**		**144.72**	**143.86**	**143.89**

Basis

! Charter discharge norms Chemical Pulp Mills 40 m^3 / t paper

 # For 100 m^3/hr, RO Membrane requirement shall be 110 Nos. @ Rs 40000 / membrane and expected life 1 year Therefore Membrane Cost Rs 44 lacs / annum or 5,24 /m^3)

**Considering 8 m height and approx 0.158 m2/MT of solid mixed salt based on VEPL CHWTSDF Nagpur - 120000 MT capacity, 8 meters (4 below ground + 4 above ground) 19000 m2 area)*

***@ Rs 6 Crores per Hectare with land cost, compaction, HDPE double liners, (prevailing market figures)*

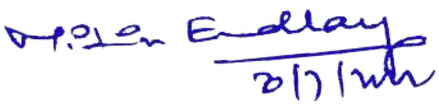
****'@ RS 200 /T considering about 10 km away from mills site*

Ø One Engineers in Shifts @ Rs 4 LPA, 3 operators in shifts @ 3 LPA, One Head of operations @ Rs 6 LPA, Maintenance Team 3 person @ Rs 3 LPA, Casual 3 @ Rs 1.5 LPA

Ø Ø Two Engineers in Shifts @ Rs 4 LPA, 6 operators in shifts @ 3 LPA, One Head of operations @ Rs 6 LPA, Maintenance Team 4 person @ Rs 3 LPA , Casual 6 @ Rs 1.5 LPA

Ø Ø Ø Three Engineers in Shifts @ Rs 4 LPA, 9 operators in shifts @ 3 LPA, One Head of operations @ Rs 6 LPA, Maintenance Team 9 person @ Rs 3 LPA, Casual 9 @ Rs 1.5 LPA

As indicated above , the additional cost for ZLD has been estimated to be around Rs 145 / m^3 which is difficult to absorb in cost of production . As such the implementation of ZLD concept through standalone effluent treatment facility would render the mills unviable to operate.



Chapter 6

OBSERVATIONS & REMARKS

Based on the data and information collected from pulp and paper mills through IPMA , interaction with various pulp and paper mills, stake holders as well as its own data base, information and literature survey carried out and CPPRI's experience through visits to various pulp & paper mills pan India, CPPRI has following observations and remarks to make:

- In recent years the Large Integrated Pulp & Paper Mills (Wood & Agro based) producing writing and printing grade of paper and paper boards have made significant improvement in their technological and environmental status making substantial capital investment.

- In last 5-10 years the mills have made significant investments for adoption of latest modern fiber line **Best Available Technologies / Best Practicable Technologies/ Bare Minimum Technologies** to improve their technological and environmental status, cost competitiveness and significant improvement in process efficiency and product quality.

- A summarised status of major technologies adopted by these mills is as under :

Technology	% of Mills
Wet Washing of Agro Residues with back water / treated effluent	**100 %**
Continuous Digester for Pulping of Agro Residues	**100 %**
New Generation Pulp Washer (Press etc)	**50- 60 %**

Elemental Chlorine Free Bleaching (ECF) **Wood** **Agro**	 **100 %** **80-90 %**
Total Chlorine Free Bleaching (TCF)	**1Mill**
Fiber Recovery System	**100%**
Chemical Recovery	**100 %**
Effluent Treatment Plant up to Tertiary Treatment	**90%**
Biomethanation for Wet washing (in Mills using Agro residues)	**All mills**
Lime Kiln (wood based)	**All Mills**
Sludge Dewatering Systems	**All Mills**

- Even though the capability of ZLD for waste minimization, resource recovery, wastewater treatment and mitigation of potential impacts on water quality of receiving streams is theoretically studied, their application on mill scale are limited due to very high capital cost, increased energy consumption and uncertainty about the final outcome

- Moreover , the available literature survey carried out in context of preparation of the report also substantiate the fact that there is no reported reference of ZLD of mill scale ZLD system operational in pulp and paper mills any where in the world which indicates its practical unfeasibility / unviability in the existing scenario . Data / information of some national / international reports referred are shared as under :

Reference	**Data / information**
World Bank IFC Environmental , Health & Safety Guidelines , Pulp and Paper Mills Good International Industry Practices (GIIP) Table 1(a) – Effluent	The effluent discharge for best achieved are given as 50 m^3/ ADT bleached kraft pulp

Guidelines for Pulp & Paper Facilities – Bleached Pulp Kraft Integrated , page 26 **(Annexure –III)**	
IL& FS EIA Guidelines published by Ministry of Environment & Forests , March 2010 , page 3-46 , Table 3- 30 **(Annexure –IV)**	The global best achieved specific water consumption is given as 41.8 / BDMT pulp
Sustainability report of Confederation of European Industries (CEPI) 2013 **(Annexure –V)**	92% of the treated effluent is discharged to surface water which implies no mill in Europe is a ZLD mill. It also shows that there is no ZLD restrictions in European industry.
Techno-economic feasibility of Implementation of ZLD for Water Polluting Industries (CPCB Report 2015)) **(Annexure –VI)**	• For the present Zero Liquid Discharge is techno-economically not feasible for most of the mill categories, No country has therefore imposed a ZLD condition for the paper industry. • Pulp & Paper Industry world wide has been exploring the ZLD concept over last two decades but has not been able to identify a technically feasible, economically viable and sustainable technology to achieve ZLD . • The two possible options which have been explored are : (a) Close up as process water loops by total recycling inside a process sequence or into different process sequence within the mill (b) Treat the effluent in a stand alone

	facility to render a suitable process reuse and volume reduction

- The options indicated in the above mentioned CPCB report are unviable as:
- Closing process loops without technology intervention will result in deterioration of product quality due to build up of TSS , TDS , COD etc as well as increased pollution load at ETP.
- Alternatively setting up stand alone facility comprising of Ultra ,Nano & Reverse Osmosis and Multiple Effect evaporater are highly energy intensive and economically non viable . An approximate theoretical estimate of operating cost of ZLD system as indicated in **Chapter 5** is around **145 / m^3**. Such an elaborate set up for any pulp and paper industry will be huge and complex and not practically implementable in context of scale of operation of most of the large pulp and paper mills.

- The performance of a small pilot plant for ZLD system incorporating treatment of tertiary treated effluent through combination of membrane technology , MVR & AFTD installed by an agro based paper mill looks promising in terms of reduction in TDS , COD, Color and recovery of water as indicated in **Table 6.1** .

- However, it has several operational issues including inconsistent operations, scale build up , frequent choking of membranes, disposal of sludge etc and looks unviable.

- Also the operating cost is still quite high for Pulp & Paper Mills to absorb in Indian perspective even if it is considered as an option.

Table 6.1 Performance of ZLD System (Membrane Technology , MVR & AFTD)

S.No	Parameter	ETP Media filter Outlet	Bag Filter Outlet	UF Outlet	RO Permeate	MVR Feed	MVR Condensate	ATFD Feed	ATFD Outlet
1.	pH	7.5	7.4	7.2	6.5	6.5	8	6.5	7
2	TSS mg/l	25	12	2	Nil	60	Nil	-	-
3	COD mg/l	120	116	110	nil	1200	Nil	-	-
4	TDS mg/l	1900	1900	1850	100	6500	25	-	-
5	Silica mg/l	15	13	12	<1	65	Nil	-	-
6	Chloride mg/l	650	630	625	15	3100	45	-	-
7	T. Hardness mg/l	750	740	740	<10	3400	Nil	-	-
8	Total Solid %	-	-	-	-	0.7	Nil	25 to 30	Powder form

- Though the propagation of concept of **Zero Liquid Discharge in Pulp & Paper Industry** by regulatory authorities is welcome in principle in context of water conservation but it has several practical limitations / bottlenecks specially in context of paper mills producing writing and printing grade of paper and boards and speciality papers due to adverse impact in process operations and product quality (without technological intervention) and techno-economic feasibility of available ZLD systems (with technological intervention).

- The adoption of technologies like membrane technologies along with MVR for achieving Zero Liquid Discharge is to be looked through prism of techno economic feasibility specially in Indian perspective where the mills operate on a wide range of scale of operation , use diverse raw materials and wide spectrum of paper products produced by the same mill.

- In context of membrane filtration system energy requirements along with other related expenses are much higher than conventional wastewater treatment and disposal option.

- Further most of the ZLD related technologies consume valuable resource like (energy , and chemicals) which itself has cross medium environment impact including contribution to carbon emissions.

- Thus there is a need to find alternatives to energy-intensive evaporator/crystallizer systems which is non proven at commercial scale. Application of kidney technologies like membrane filtration system (ultra filtration / reverse osmosis) is also associated with problems of disposal of mother liquor and salts for which cost effective solution is yet to be explored nor there are any existing waste management facilities which can receive these mother liquor and salts for environmentally safe disposal.

- Further in terms of environmental concerns, more studies are needed for life-cycle assessment of energy demand and greenhouse gas emissions to improve understanding of the cost-benefit of ZLD systems.

- Use of diverse fibrous raw materials and producing different grades of products makes the optimisation of water consumption really challenging. More over mills producing speciality grade / food packaging / hygienic paper products require extremely high standard of process water quality as well as cleaning of paper machines and equipments which makes ZLD almost impossible

- It is also to be noted that in some drains / tributaries(which are seasonal) the pulp & paper mill treated effluent discharged is used in down stream by farmers for irrigation. Over emphasis on ZLD may impact the availability of water to farming community accordingly

- Most of the Large Pulp & Paper Mills are supporting the farmer community by providing treated effluent for irrigation / cultivation thus indirectly aiding in saving fresh water consumtion for agriculture . Many Pulp & Paper Mills have even facilitated network of irrigation for providing treated effluent to local farmers. However , this depends on the location of the mill , availability of land and involvement of framers, type of crops, requirement of farmers and local environment.

- Most of the receiving streams in India are seasonal with lean flow during most of the year. In some cases the discharge from pulp and paper industry is the only source for dilution of pollution load from different sources (Municipal Sewage / House Hold Waste etc) in the river.

- To encourage ZLD there is a need for a pilot scale demonstration of appropriate ZLD technologies / systems such as membrane filtration , crystallization , ozone treatment as advocated by regulators / policy makers for evaluation of their relevance , applicability as well as suitability in Indian context without jeopardizing the competiveness of the industry.

- Recently a fresh attempt is being made under a **UNIDO Paper Project Phase II - A Firm-level Demonstration of Technologies and Productivity Enhancement for the Pulp and Paper Industry** to demonstrate feasibility of Membrane Filtration in Indian Pulp & Paper Industry . Under the project skid mounted pilot scale reactor employing ultra filtration and nano filtration modules is being developed to conduct trials for treatment of various specific stream like paper machine back water, secondary clarifier outlet , E stage bleach plant effluent etc in selected pulp and paper mills of using diverse raw materials (wood , agro and RCF based) across the country to evaluate its feasibility and techno-economic viability in context of significant reduction in fresh water consumption , waste water discharged and pollution load in recent years . The Pre-Pilot Trials in an agro based pulp & paper mills has already been initiated and the pilot scale trials are likely to be undertaken soon.

- There is a need for incentivisation and recognition of the pulp and paper mills (including other industries) achieving / setting up new benchmarks in area of water conservation or contributing significantly towards reduction in water footprint, increase in ground water level etc. Further various incentive-based instruments such as subsidies / tax or duty exemptions on technologies / equipments facilitating ZLD are required to encourage pulp and paper mills to consider adoption of ZLD once it is proven through pilot plant and scale up operation studies.

- The Pulp & Paper Industry in recent years have invested significantly to adopt BMT / BPT / BAT to meet the stringent fresh water consumption & waste water discharge norms as well as pollution norms under the CPCB Charter. No doubt while regulations are necessary for addressing the environmental impact, directives for ZLD without any feasibility study could also hamper the industry's growth and sustainability.

- In all at present , ZLD is still an evolving concept / technology specially in context of Pulp & Paper sector. There is still no reported example of mill scale operation of zero liquid discharge system in pulp and paper mills producing writing and printing grade of paper . Thus there is a need for evaluation / demonstration of techno- economic feasibility of appropriate ZLD systems on following counts before ZLD is made mandatory.

- Extent of water recovery possible
- Sustainability on basis of 24x7 operations
- Operation & Maintenance costs
- Upstream changes required
- Cross-media environmental impacts

- As such in present scenario minimum water fresh water consumption **of <50 m^3 / t paper for Chemical Pulp Mills producing Writing & Printing Grade of Paper from Wood & Agro residues Pulp & Paper Mills** seems to be justified in present scenario till techno –economically viable option for complete reuse / recycle of treated effluent is available.

- Till then the Pulp & Paper Mills should focus more on :
- Optimizing the fresh water consumption as there is still a scope of further reduction in fresh water consumption
- Color removal in treated effluent .
- Increase / recycle of various back water streams & treated effluent
- Wherever local conditions permit and practically possible, maximize treated water use for irrigation

Note: This is purely a technical opinion based on the CPPRI experience, inputs from pulp and paper mills / technology suppliers, literature available etc . This report cannot be deemed to be a certificate for any legal implications.

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ANNEXURE

Annexure - I

General Process Employed in Paper Making

Raw Material Preparation

In the wood based pulp and paper mills the wood logs **(Fig 1)** are usually washed with treated effluent and chipped into appropriate size in the chipper house **(Fig 2)** , screened and subsequently stored in a chip silo.

In agro based pulp and paper mills **dedusting** and **wet washing (Fig 3 & 4)** is carried out for cleaning of wheat straw for removal of recalcitrant like silica as well as potassium and chloride to improve the pulp quality as well as properties of black liquor generated during pulping which otherwise causes problem in chemical recovery boiler.

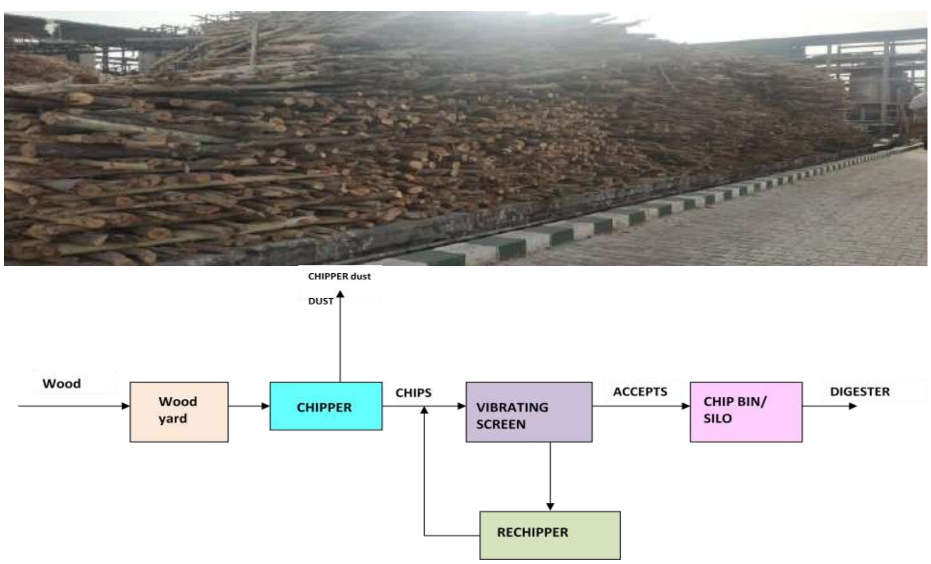


Fig 1 Chipper House

Fig 2 Chipper House

Fig 3 Agro Residues Storage

Fig 4 Wet Washing of Agro residues

Pulping

The wood chips are cooked in **stationary digesters (Fig 5) using sodium hydroxide &sodium Sulphide as well as pulping aids / additives (as per requirement)** . The cooking cycle is generally of around 5-6 hours and temperature 150- 180 ^{o}C .

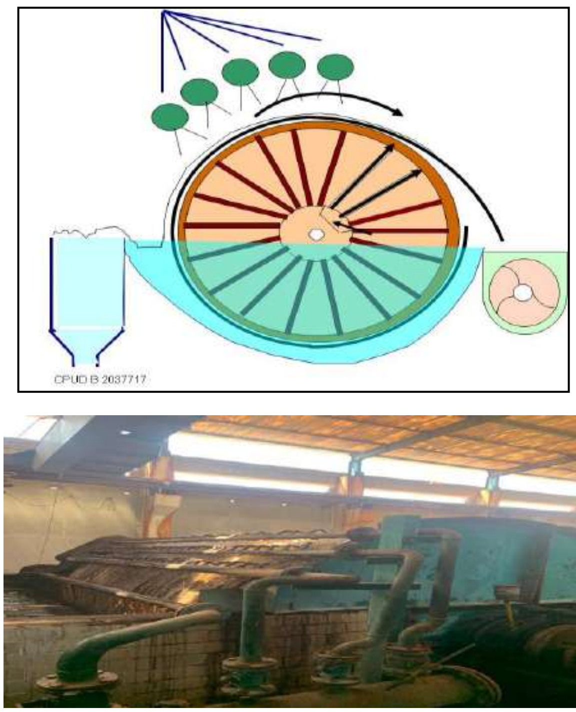
The agro residues are also cooked in digesters (Present trend : continuous digesters **(Fig 6**)) at a pressure of 6- 8 kg / cm^2 pressure and temperature of 160- 165 ^{o}C using NaOH as cooking chemical

Fig 5 Stationary Digester

Fig 6 Continuous Digester

Pulp Washing

The cooked pulp is blown to the blow tank and then subjected to several screening followed by pulp washing . The conventional pulp washing system is brown stick washer **(Fig 7)** but the recent trends have been switch over to more water efficient washers like twin roll press **(Fig 8)** etc.



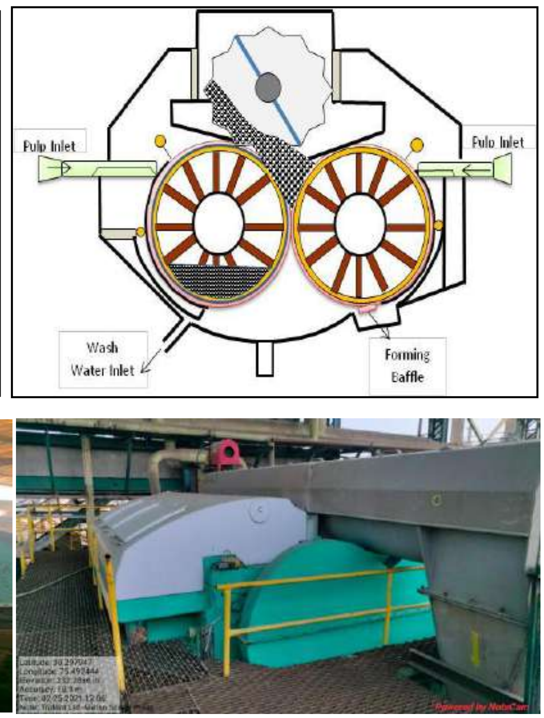


Fig 7 Brown stock Washer **Fig 8 Twin Roll Press**

The comparative advantage of Twin Roll Press over conventional Brown stock Washer is indicated in **Table 1 .**

Table 1 COD Carryover and Impact on Black Liquor Solids with Conventional BSW / Twin Roll Press

Particulars	Unit	BSW	Twin roll press
COD carryover	kg/Ton pulp	12	8
Black liquor solids (agro residues)	% w/w	10	12
Black liquor solids (Wood)	% w/w	13	16
Wash liquor at dilution factor 2.5	m^3/Ton	9.8	4.8
Outlet consistency	%	12	28

Note: All Figures are Average Values

Oxygen Delignification (ODL)

Oxygen delignification **(Fig 9 & 10)** can be considered as a pretreatment step before Pulp Bleaching. ODL helps in reducing the kappa number of the pulp by over 40% thus facilitating less chemical consumption in subsequent pulp washing leading to significant reduction in pollution load generation . Due to these advantages many mills specially wood based have adopted ODL in their process operations

Fig 9 ODL Press

Fig 10 Oxygen Reactor

Pulp Bleaching

Post pulp washing the unbleached pulp is bleached using either Conventional Pulp Chlorine based Bleaching Sequence like CEHH or **Elemental Chlorine Free Bleaching) sequence like $D_oE_{op}D1$ etc** . Conventional chlorine based bleaching results in high pollution laod specially in context of adsorbable organic halides (AOX). In this context over last few years many wood based pulp and paper mills have switched over to Elemental Chlorine Free Bleaching (ECF) employing chlorine dioxide has principal bleaching agent which results in low AOX generation

Stock Preparation & Paper Making

Pulp is conditioned in the stock preparation section for bondage to form sheet. The pulp received from pulp mill is passed through a series of refiners for fibrillation and then the required additives viz. **fillers, dyes, whitening agents, resin and alum** are added to impart functional properties such as opacity, reflectance, shade and water resistance. The final blended stock is pumped to paper machine chest.

The blended stock in very dilute suspension is allowed to flow from Head Box and spread on a moving wire part of paper machine **(Fig 2.13)** where water is drained and fibre binds together to form a wet web. The wet paper web is pressed, dried, calendered and finally sent to finishing section

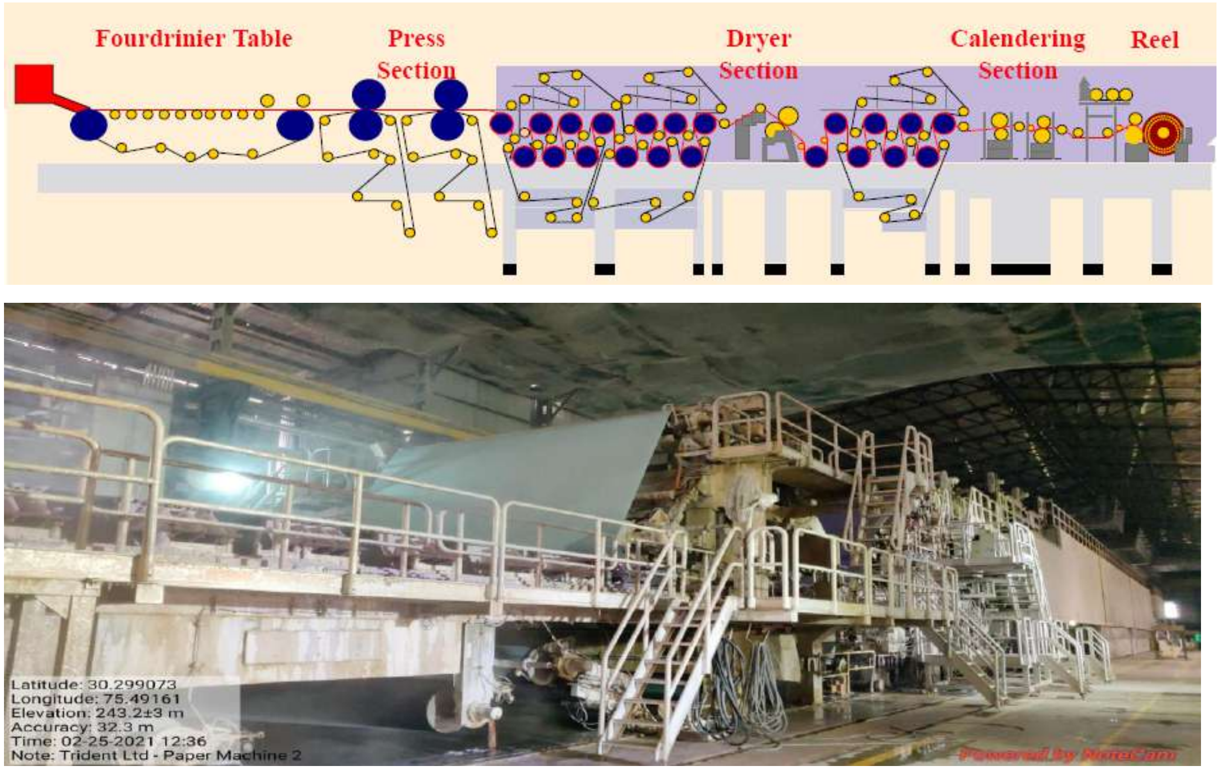


Fig 11 Paper Machine

Chemical Recovery Plant

The chemical recovery system **(Fig 12)** involves multiple effect evaporators, chemical recovery boilers and lime kiln The black liquor is concentrated , burnt in recovery boiler to generate smelt which is extracted with water to convert into green liquor. The green liqauor is causticised with lime to regerenerate sodium hydroxide as well as caclcium carbonate as by product. The lime sludge thus generated is incinerated in lime kiln to regenerate lime

Fig 12 Multiple Effect Evaporaters

Effluent Treatment Plant (ETP)

Almost all the mills in general have similar type of configuration for effluent treatment plant which based on activated sludge process . The ETP mainly comprise of equalization tank , primary clarifier , aeration tank , secondary clarifier , tertiary treatment system , and sludge dewatering system**.(Fig 13)**

Wastewater generated from process operations pulp mill, paper machines, power boilers and recovery boilers having low COD which is first collected in a **Equalization Tank (Fig 14)** to avoid fluctuation in pollution load entering ETP and subsequently clarified in a **Primary Clarifier No** (**Fig 15)** for removal of suspended solids to reduce pollution load of the effluent stream entering aeration tank .

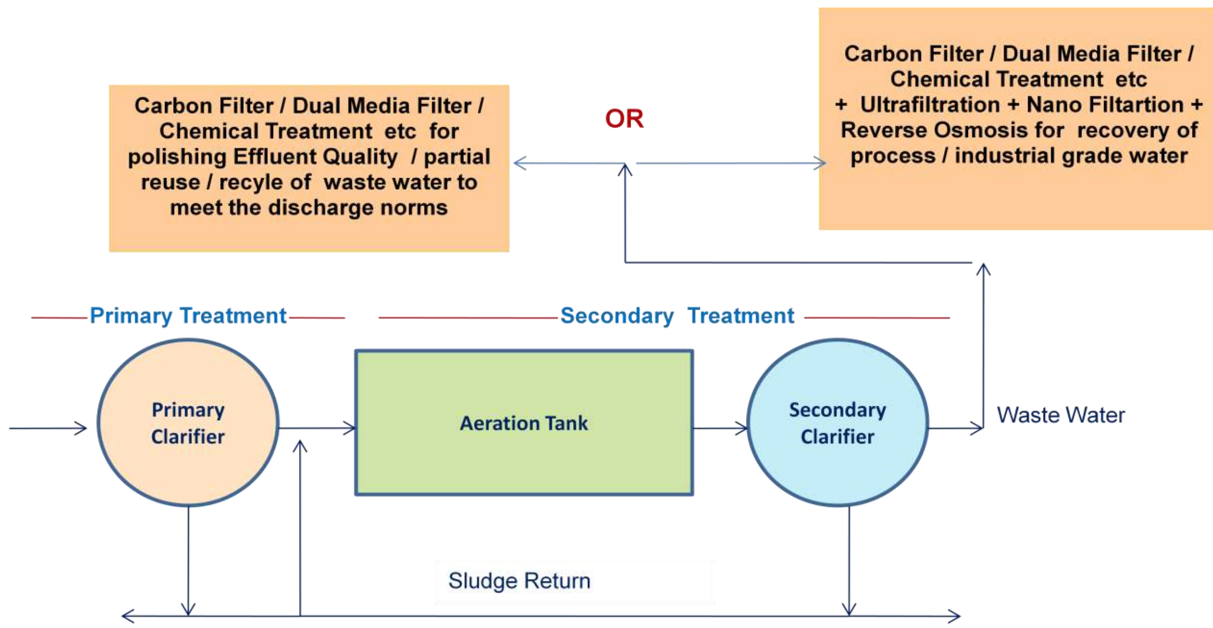


Fig 13 Effluent Treatment Plant in Wood / Agro Pulp & Paper Mills

Fig 14 EqualizationTank

Fig 15 Primary Clarifier

After clarification, the waste water is pumped into **Aeration Tanks** equipped with **diffused aerators / surface aerators** to maintain the dissolved oxygen level required for proper metabolic activity of microbial culture. **(Fig 16).**

Fig 16 Aeration tank

The overflow of wastewater from aeration tank goes into secondary clarifier **(Fig 17)** for settling of biomass. The settled biomass is recirculated to aeration tank to maintain the adequate MLSS level in aeration tank while the rest is disposed off.

Fig 17 Secondary Clarifier

The clarified effluent is further subjected to tertiary treatment **(Fig 18)** involving **dual media filter , sand filter , activated carbon filter** to further polish the effluent quality and meet the stipulated norms.

Fig 18 Tertiary Treatment System

Annexure - II

Material Balance & Water Balance Of A 415 Tpd Of Writing & Printing Grade of Paper and .Having Both Straw Fiber Line As Well As Wood Fiber Line

Material Balance- SFL (Consolidated)

Input			Output		
Sr. No.	**Description**	**TPD**	**Sr. No.**	**Description**	**TPD**
i.	Wheat Straw (BD)	**535**	i.	Dust Separated from Deduster @ 3 % of Wheat Straw	16.05
ii.	White Liquor (700 m^3 @ 11.4 % solids)	79.8	ii.	Dust Separated from Wet Washing System @ 2 % of Wheat Straw	10.7
			iii.	Rejects Separated from Knotter Screen and HD Cleaner @ 1.5 % of Cooked Pulp	3.625
			iv.	Rejects Separated from Pressure Screens and Centri-Cleaners @ 0.5 % of Cooked Pulp	1.208
			v.	Shrinkage loss during Bleaching @ 5 % of Unbleached Pulp	11.842
			vi.	Solids in Weak Black Liquor Generated (3150 TPD Weak Black Liquor @ 11 % Solids)	346.5
			vii.	**Bleached Pulp Produced**	**225**
	Total	**614.8**		**Total**	**614.925**

Water & Material Balance- SFL (Section Wise)

Section: Wheat Straw Dry Cleaning (Dedusting)

Input		Output	
Description	**TPD**	**Description**	**TPD**
Wheat Straw (BD)	535	Wheat Straw after Dry Cleaning	518.95
		Dust Separated from Deduster @ 3.0 % of Wheat Straw	**16.05**
Total	**535**	**Total**	**535**

Section: Wheat Straw Wet Washing @ 3 % Consistency

Inputs (TPD)		Outputs (TPD)	
Description	**TPD**	**Description**	**TPD**
Wheat Straw after Dry Cleaning (BD)	518.95	Wheat Straw after Wet Washing	508.25
Moisture Carryover with Wheat Straw @ 8 %	45.126	Dust Separated from Wet washing System @ 2.0 % of Wheat Straw	10.7
Black Liquor Secondary Condensate	2085	Water carryover with washed wheat straw @ 40 % dryness	762.375
Wet Washing Clarifier Overflow	14017.008	Wet Washing Clarifier Overflow to Wash Beater	**14017.008**
Fresh Water	**632.249**	Wet Washing Clarifier Underflow to ETP	2000
Total	**17298.333**	**Total**	**17298.333**

Section: Wheat Straw Pulping, Cold Blowing & Pulp Washing

a. Wheat Straw Pulping (Bath Ratio= 1:3.5)

Input		Output	
Description	**TPD**	**Description**	**TPD**
Washed Wheat Straw	508.25	Cooked Pulp @ 45 %	241.676
Water Carryover with Washed Wheat Straw	762.375	Spent liquor	2045.449
White Liquor (Active Alkali as NaOH- 100 gpl)	700		
LP Steam to Digester	316.5		
Total	**2287.125**	**Total**	**2287.125**

b. Section: Pulp Cold Blowing (Consistency: 4 %)

Inputs		Outputs	
Description	**TPD**	**Description**	**TPD**
Cooked Pulp	241.676	Cooked Pulp	241.676
Spent liquor	2045.449	Liquor in Blow Tank	5800.224
BSW (1&2) Filtrate for Dilution	3754.775		
Total	**6041.9**	**Total**	**6041.9**

c. Section: Knott Screening & High Density Cleaning (Consistency: 2.5 %)

Input		Output	
Description	**TPD**	**Description**	**TPD**
Cooked Pulp	241.676	Pulp after Knot Screen & HD cleaner	238.051
Liquor in Blow Tank	5800.224	Rejects from Knot Screen & HD cleaner	3.625
BSW (1&2) Filtrate for Dilution	3625.14	Liquor with Pulp	9425.364
Total	**9667.04**	**Total**	**9667.04**

d. Section: Brown Stock Washers-1 & 2 (Dry End Cy. 11 %)

Input		Output	
Description	**TPD**	**Description**	**TPD**
Pulp after Knot Screen & HD Cleaner	238.051	Pulp after BSW (1 &2)	238.051
Liquor with Pulp	9425.364	Water with Pulp after BSW (1 &2)	1926.049
Twin Roll Press-1 Filtrate in Spray Showers	1248.519	Liquor to BSW (1 & 2) Filtrate Tank	7379.915
BSW (3&4) Filtrate in Spray Showers	1782.081	Liquor to BSW (1 & 2) Filtrate Tank (Chemical Recovery System)	3150
Total	**12694.015**	**Total**	**12694.015**

e. Section: Twin Roll Press-1 (Dry End Cy: 26 %)

Inputs		Outputs	
Description	**TPD**	**Description**	**TPD**
Pulp after BSW (1 &2)	238.051	Pulp after Twin Roll Press-1	238.051
Water Carryover with Pulp after BSW (1&2)	1926.049	Water with Pulp after Twin Roll Press	677.530
		Liquor to Twin Roll Press-1 Filtrate Tank	1248.519
Total	**2164.1**	**Total**	**2164.1**

f. Section: Primary & Secondary Screening followed by Centri-cleaning (Cy.: 2.5 %)

Inputs		Outputs	
Description	**TPD**	**Description**	**TPD**
Pulp after Twin Roll Press-1	238.051	Pulp after Screening & Cleaning	236.843
Water Carryover with Pulp after Twin Roll Press-1	677.530	Rejects from Pressure Screens & Centri-cleaners	1.208
BSW (3&4) Filtrate for Dilution	8606.459	Liquor with Pulp	9283.989
Total	**9522.04**	**Total**	**9522.04**

g. Section: Brown Stock Washers-3 & 4 (Dry End Cy. 11 %)

Inputs		Outputs	
Description	**TPD**	**Description**	**TPD**
Pulp after Screening & Cleaning	236.843	Pulp after BSW (1 &2)	236.843
Liquor with Pulp	9283.989	Water with Pulp after BSW (3 &4)	1916.275
Twin Roll Press -2 Filtrate in Spray Showers	1242.183	Liquor to BSW (3 & 4) Filtrate Tank	10388.54
Twin Roll Press -3 Filtrate in Spray Showers	1778.643		
Total	**12541.658**	**Total**	**12541.658**

h. Section: Twin Roll Press-2 (Dry End Cy: 26 %)

Input		Output	
Description	**TPD**	**Description**	**TPD**
Pulp after BSW (3 &4)	236.843	Pulp after Twin Roll Press-2	236.843
Water Carryover with Pulp after BSW (3&4)	1916.275	Water with Pulp after Twin Roll Press-2	674.092
		Liquor to Twin Roll Press -2 Filtrate Tank	1242.183
Total	**2153.118**	**Total**	**2153.118**

i. Section: ODL Reactor and Twin Roll Press-3 (Dry End Cy: 26 %)

Inputs		Outputs	
Description	**TPD**	**Description**	**TPD**
Pulp after Twin Roll Press-2	236.843	Pulp after Twin Roll Press	236.843
Water Carryover with Pulp after Twin Roll Press-2	674.092	Water with Pulp after Twin Roll Press-3	674.092
Fresh Water for Dilution	1778.643	Liquor to Twin Roll Press-3 Filtrate Tank	1778.643
Total	**2689.578**	**Total**	**2689.578**

Section: Bleaching

a) D_0 Stage (D_0 Reactor + Twin Roll Press-4)

Wet End Consistency: 8 %, Dry End Consistency: 26 %,

Inputs		Outputs	
Description	**TPD**	**Description**	**TPD**
Unbleached Pulp	236.843	Pulp after D_0 Stage	234.474
Water Carryover with Unbleached Pulp	674.092	Water with D_0 Stage Pulp	667.348
Chlorine Di Oxide (ClO_2)- 9.2 gpl @ 10.8 kg per tonne of bleached pulp	264.13	D_o Twin Roll Press-4 Filtrate	1785.472
D_0 Filtrate for Dilution	1785.472	D_o Twin Roll Press-4 Filtrate (to ETP)	993.243
Fresh Water in Spray Shower	720		
Total	**3680.537**	**Total**	**3680.537**

b) E_{op} Stage (E_{op} Reactor + Twin Roll Press-5)

Wet End Consistency: 8 %, Dry End Consistency: 26 %

Inputs		Outputs	
Description	**TPD**	**Description**	**TPD**
Pulp after D_a Stage	234.474	Pulp after E_{op} Stage	229.737
Water Carryover with D_0 Stage pulp	667.348	Water with E_{op} Stage Pulp	653.866
Sodium Hydroxide (NaOH) @ 15 kg per tonne of bleached pulp	3.375	E_{op} Twin Roll Press-5 Filtrate (Reused)	2026.561
Hydrogen Peroxide (H_2O_2)-50 % @	2.542	E_{op} Twin Roll Press-5 Filtrate	620.761

11.3 kg per tonne of bleached pulp		(to ETP)	
E_{op} Filtrate for Dilution	2026.561		
Fresh Water in Spray Shower	600		
Total	**3530.925**	**Total**	**3530.925**

c) D_1 Stage (D_1 Reactor + Twin Roll Press-6)

Wet End Consistency: 8 %, Dry End Consistency: 26 %,

Inputs		**Outputs**	
Description	**TPD**	**Description**	**TPD**
Pulp after E_{0p} Stage	229.737	Pulp after D_1 Stage	225
Water Carryover with E_{op} Stage Pulp	653.866	Water with D_1 Stage Pulp	640.384
Chlorine Di Oxide (ClO_2)- 9.2 gpl @ 7.2 kg per tonne of bleached pulp	176.09	D_1 Twin Roll Press-6 Filtrate (Reused)	1812.019
D_1 Filtrate for Dilution	1812.019	D_1 Twin Roll Press-6 Filtrate (Sent to ETP)	694.309
Fresh Water in Spray Shower	500		
Total	**3371.712**	**Total**	**3371.712**

Material & Water Balance- Wood Fibre Line (WFL)

Material Balance- WFL (Consolidated)

Input			**Output**		
Sr. No.	**Description**	**TPD**	**Sr. No.**	**Description**	**TPD**
i.	**Wood Chips** (75 % Veneer Chips & 25% Logs Chips)	144.5	i.	Dust Separated from Chip Screen @ 2.5 % of Wood Chips	3.613
ii.	White Liquor (351 m^3 @ 11.4 % Solids)	40	ii.	Rejects Separated from Knotter Screen @ 1.5 % of Cooked Pulp	1.047
iii.	Weak Black Liquor (50 m^3 @ 16.5 % Solids)	8.3	iii.	Rejects Separated from Primary & Secondary Screens @ 0.5 % of Cooked Pulp	0.349
			iv.	Shrinkage loss during Bleaching @ 5.0 % of Unbleached Pulp	3.421
			v.	Solids in Weak Black Liquor Generated (724 TPD weak black liquor @ 16.5 % solids)	119.5
			vi.	**Bleached Pulp Produced**	**65**
	Total	**192.8**		**Total**	**192.93**

Material and Water Balance-Wood Fibre Line (WFL)

Section: Octagonal Screen (Chips Screening)

Input		Output	
Description	**TPD**	**Description**	**TPD**
Wood Chips (75 % Veneer Chips & 25 % Log Chips)	144.5	Screened Wood Chips	140.887
		Dust Separated from Chip Screen @ 2.5 % of Wood Chips	3.613
Total	**144.5**	**Total**	**144.5**

Section: Vertical Batch Digesters (Wood Pulping, Bath Ratio ~ 1:3.5)

Input		Output	
Description	**TPD**	**Description**	**TPD**
Screened Wood Chips	140.887	Cooked Pulp	69.817
Moisture Carryover with Wood Chips @ 40 %	93.925	Spent liquor	565.995
White Liquor	351		
Weak Black Liquor (BSW-1 Filtrate)	50		
Total	**635.812**	**Total**	**635.812**

Section: Blow Tank with Heat Recovery System (Hot Blowing)

Inputs		Outputs	
Description	**TPD**	**Description**	**TPD**
Cooked Pulp	69.817	Cooked Pulp	69.817
Spent liquor	565.995	Spent liquor	547.995
		Blow Tank Vapor Condensate	18
Total	**635.812**	**Total**	**635.812**

Section: Knotter Screen (Pulp Screening) - Cy: 2.5 %

Inputs		Outputs	
Description	**TPD**	**Description**	**TPD**
Cooked Pulp	69.817	Pulp after Knotter Screen	68.77
Spent liquor	547.995	Knotter Screen Rejects @ 1.5 % of Cooked Pulp	1.047
BSW-1 Filtrate for Dilution	2174.868	Liquor with Pulp	2722.863
Total	**2792.68**	**Total**	**2792.68**

Section: Pulp Washing

a) Brown Stock Washer-1 (Dry End Cy. 11 %)

Inputs		**Outputs**	
Description	**TPD**	**Description**	**TPD**
Pulp after Knotter Screen	68.77	Pulp after BSW-1	68.77
Liquor with Pulp	2722.863	Water with Pulp	556.412
BSW-2 Filtrate in Spray Showers	782.417	BSW-1 Filtrate (Reused)	2224.868
		BSW-1 Filtrate (to Chemical Recovery System)	724
Total	**3574.05**	**Total**	**3574.05**

b) Brown Stock Washer-2 (Wet End Cy: 2.0 %, Dry End Cy: 11 %)

Inputs		**Outputs**	
Description	**TPD**	**Description**	**TPD**
Pulp after BSW-1	68.77	Pulp after BSW-2	68.77
Water with Pulp	556.412	Water with Pulp	556.412
BSW-2 Filtrate for Dilution	2030.901	BSW-2 Filtrate	2813.318
BSW-3 Filtrate in Spray Showers	782.417		
Total	**3438.5**	**Total**	**3438.5**

c) Brown Stock Washer-3 (Wet End Cy: 2.0 %, Dry End Cy: 11 %)

Inputs		**Outputs**	
Description	**TPD**	**Description**	**TPD**
Pulp after BSW-2	68.77	Pulp after BSW-3	68.77
Water with Pulp	556.412	Water with Pulp	556.412
BSW-3 Filtrate for Dilution	2030.901	BSW-3 Filtrate	2813.318
BSW-4 Filtrate in Spray Showers	**782.417**		
Total	**3438.5**	**Total**	**3438.5**

d) Primary & Secondary Pressure Screens- Cy: 2.5 %

Inputs		**Outputs**	
Description	**TPD**	**Description**	**TPD**
Pulp after BSW-3	68.77	Pulp after Pressure Screens	68.421
Water with Pulp	556.412	Rejects @ 0.5 % of Cooked Pulp	0.349
BSW-4 Filtrate for Dilution	2125.618	Liquor with Pulp	2682.03
Total	**2750.8**	**Total**	**2750.8**

e) Brown Stock Washer-4 (Dry End Cy: 11 %)

Inputs		Outputs	
Description	**TPD**	**Description**	**TPD**
Pulp after Pressure Screens	68.421	Pulp after BSW-4	68.421
Liquor with Pulp	2682.03	Water with Pulp after BSW-4	553.588
ODL Washer-1 Filtrate in Spray Shower	779.593	BSW-4 Filtrate	2908.035
Total	**3530.044**	**Total**	**3530.044**

Section: Oxygen Delignification (ODL)

a) ODL Reactor (Cy. 8.0 %)

Inputs		Outputs	
Description	**TPD**	**Description**	**TPD**
Pulp after BSW-4	68.421	Pulp in ODL Reactor	68.421
Water with Pulp after BSW-4	553.588	Liquor with Pulp in ODL Reactor	787.621
Caustic as NaOH @ 12 kg/tone of Bleached Pulp	0.78		
ODL Washer-1 Filtrate for Dilution	**233.253**		
Total	**856.042**	**Total**	**856.042**

b) **ODL Washer-1 (Wet End Cy.: 1.75 %, Dry End Cy: 10.5 %)**

Inputs		Outputs	
Description	**TPD**	**Description**	**TPD**
Pulp in ODL Reactor	68.421	Pulp after ODL Washer-1	68.421
Liquor with Pulp in ODL Reactor	787.621	Water with Pulp after ODL Washer-1	583.207
ODL Washer-1 Filtrate for Dilution	3053.729	ODL Washer-1 Filtrate	4066.575
ODL Washer-2 Filtrate in Spray Showers	808.432		
Total	**4718.203**	**Total**	**4718.203**

c) ODL Washer-2 (Wet End Cy.: 1.75 %, Dry End Cy: 10.5 %)

Inputs		Outputs	
Description	**TPD**	**Description**	**TPD**
Pulp after ODL Washer-1	68.421	Pulp after ODL Washer-2 (Unbleached Pulp)	68.421
Water with Pulp after ODL Washer-1	583.207	Water with Pulp after ODL Washer-2	583.207
ODL Washer-2 Filtrate for Dilution	3258.143	ODL Washer-2 Filtrate	4066.575
Fresh Water in Spray Showers	808.432		
Total	**4718.203**	**Total**	**4718.203**

Section: Pulp Bleaching

a) D_0 Reactor (Cy. 7.5 %)

Inputs		Outputs	
Description	**TPD**	**Description**	**TPD**
Unbleached Pulp	68.421	Pulp in D_0 Reactor	68.421
Water with Unbleached Pulp	583.207	Water with Pulp in D_0 Reactor	945.595
Sulphuric Acid (H_2SO_4)-98 % @ 8 kg/tone of Bleached Pulp	0.531		
Chlorine Di Oxide (ClO_2)- 9.2 gpl @ 16 kg/tone of bleached pulp	113.04		
D_0 Washer Filtrate for Dilution	248.817		
Total	**1014.016**	**Total**	**1014.016**

b) **D_0 Washer (Wet End Cy.: 2.25 %, Dry End Cy: 10.5 %)**

Inputs		Outputs	
Description	**TPD**	**Description**	**TPD**
Pulp in D_0 Reactor	68.421	Pulp after D_0 Stage	67.737
Water with Pulp in D_0 Reactor	945.595	Water with Pulp after D_0 Stage	577.377
D_0 Washer Filtrate for Dilution	2026.917	D_0 Washer Filtrate (Reused)	2275.734
Fresh Water in Spray Showers	540	D_0 Washer Filtrate (to ETP)	660.085
Total	**3580.933**	**Total**	**3580.933**

c) E_{op} Reactor (Cy. 8.5 %)

Inputs		Outputs	
Description	**TPD**	**Description**	**TPD**
Pulp after D_a Stage	67.737	Pulp in E_{op} Reactor	67.737
Water with D_0 Stage pulp	577.377	Liquor with Pulp in E_{op} Reactor	729.169
Sodium Hydroxide (NaOH)-Solid @ 20 kg/tone of Bleached Pulp	1.3		
Hydrogen Peroxide (H_2O_2)- 60 % @ 12 kg/tone of Bleached Pulp	1.3		
LP Steam @ 0.120 tone/tone of Bleached Pulp	7.8		
E_{op} Washer Filtrate for Dilution	141.392		
Total	**796.906**	**Total**	**796.906**

d) **E_{op} Washer (Wet End Cy.: 1.75 %, Dry End Cy: 12 %)**

Inputs		Outputs	
Description	**TPD**	**Description**	**TPD**
Pulp in E_{op} Reactor	67.737	Pulp after E_{op} Stage	66.368
Liquor with Pulp in E_{op} Reactor	729.169	Water with Pulp after E_{op} Stage	486.699
E_{op} Washer Filtrate for Dilution	2623.78	E_{op} Washer Filtrate (Reused)	2765.172
D1 Washer Filtrate in Spray Showers	450	E_{op} Washer Filtrate (to ETP)	772.447
Fresh Water in Spray Showers	220		
Total	**4090.686**	**Total**	**4090.686**

e) D_1 Reactor (Cy. 7.5 %)

Inputs		Outputs	
Description	**TPD**	**Description**	**TPD**
Pulp after E_{op} Stage	66.368	Pulp in D_1 Reactor	66.368
Water with Pulp after E_{op} Stage	486.699	Water with Pulp in D_1 Reactor	840.869
Sulphuric Acid (H_2SO_4)- 98 % @ 2.5 kg/tone of Bleached Pulp	0.166		
Chlorine Di Oxide (ClO_2)- 9.2 gpl @ 3.5 kg/tone of bleached pulp	24.7		
D_1 Washer Filtrate for Dilution	329.204		
Total	**907.237**	**Total**	**907.237**

f) **D_1 Washer (Wet End Cy.: 1.75 %, Dry End Cy: 11 %)**

Inputs		Outputs	
Description	**TPD**	**Description**	**TPD**
Pulp in D_1 Reactor	66.368	Pulp after D_1 Stage (Bleached Pulp)	65
Water with Pulp in D_1 Reactor	840.869	Water with Unbleached Pulp	525.909
D_1 Washer Filtrate for Dilution	2435.22	D_1 Washer Filtrate	2764.424
Paper Machine Backwater in Spray Showers	450	D_1 Washer Filtrate (Sent to ETP)	687.124
Fresh Water in Spray Showers	250		
Total	**4042.457**	**Total**	**4042.457**

Water & Material Balance: Multi Effect Evaporators & Chemical Recovery 1 & 2

Multi Effect Evaporators (Black Liquor Evaporation)

Inputs (TPD)		Outputs (TPD)	
Description	**TPD**	**Description**	**TPD**
Weak Black Liquor from Straw Fibre Line (SFL) @ 11 % Solids	3150	Semi Concentrated Black Liquor (SCBL) @ 55 % Solids	300
Weak Black Liquor from Wood Fibre Line (WFL) @ 16.5 % Solids	724	Heavy Black Liquor (HBL) @ 69 % Solids	436
Weak White Liquor from Mud Washer-1 for Maintaining RAA	144	Steam Primary Condensate	482
Evaporator Body Washings	50	Steam Loss	53
LP Steam @ 1 tone per 6.2 tone of water evaporation	535	Black Liquor Secondary Condensate	3260
		Black Liquor Foul Condensate	72
Total	**4603**	**Total**	**4603**

Chemical Recovery-1

Section: Recovery Furnace (Semi Concentrated Black Liquor Firing)

Inputs (TPD)		Outputs (TPD)	
Description	**TPD**	**Description**	**TPD**
Semi Concentrated Black Liquor (SCBL) @ 55 % Solids	300	Smelt Produced @ 35 % of Solids	58
		Organic Matter Burnt @ 65 % of Solids	107
		Water Evaporated	135
Total	**300**	**Total**	**300**

Section: Smelt Dissolve Tank (Green Liquor Generation)

Inputs (TPD)		Outputs (TPD)	
Description	**TPD**	**Description**	**TPD**
Smelt from recovery furnace	58	Green Liquor Produced	479
Weak White Liquor (Mud Washer-1 Overflow) for Dissolving Smelt	421		
Total	**479**	**Total**	**479**

Section: Rotary Slaker, Caustisizers and Clarifier

Inputs (TPD)		Outputs (TPD)	
Description	**TPD**	**Description**	**TPD**
Green Liquor	479	White Liquor Clarifier Overflow (White Liquor)	***398***
LP Steam for Maintaining Temp	29	White Liquor Clarifier Underflow (Lime Mud)	138
Quick Lime of 80 % Purity	30	Rejects from Slaker (Grits)	2
Total	**538**	**Total**	**538**

Section: Lime Mud Washer-1 (Dilution Factor 1:4)

Inputs (TPD)		Outputs (TPD)	
Description	**TPD**	**Description**	**TPD**
White Liquor Clarifier Underflow	138	Mud Washer-1 Overflow (Weak White Liquor)	421
Mud Washer-2 Overflow for Dilution	432	Mud Washer-1 Underflow	149
Total	**570**	**Total**	**570**

Section: Lime Mud Washer-2 (Dilution Factor 1:4)

Inputs (TPD)		Outputs (TPD)	
Description	**TPD**	**Description**	**TPD**
Mud Washer-1 Underflow	149	Mud Washer-2 Overflow	432
Lime Mud Thickener Filtrate for Dilution	424	Mud Washer-2 Underflow	141
Total	**573**	**Total**	**573**

Section: Lime Mud Drum Filter

Inputs (TPD)		Outputs (TPD)	
Description	**TPD**	**Description**	**TPD**
Mud Washer-2 Underflow	141	Lime Mud after Thickening	46
Black Liquor Secondary Condensate for Dilution	76	Moisture Carryover with Lime Mud @ 50 %	46
Black Liquor Secondary Condensate in Spray Showers	299	Lime Mud Thickener Filtrate	424
Total	**516**	**Total**	**516**

Chemical Recovery-2

Section: Recovery Furnace (Liquor Solids Firing)

Inputs (TPD)		**Outputs (TPD)**	
Description	**TPD**	**Description**	**TPD**
Heavy Black Liquor (HBL) @ 69 % Solids	436	Smelt Produced @ 35 % of Solids	105
		Organic Matter Burnt @ 65 % of Solids	196
		Water Evaporated	135
Total	**436**	**Total**	**436**

Section: Recovery Furnace (Green Liquor Generation)

Inputs (TPD)		**Outputs (TPD)**	
Description	**TPD**	**Description**	**TPD**
Smelt from Recovery Furnace	105	Green Liquor Produced	876
Weak White Liquor (Mud Washer Filtrate-1) for Dissolving Smelt	771		
Total	**876**	**Total**	**876**

Section: Slaker, Caustisizers and Clarifier

Input (TPD)		**Output (TPD)**	
Description	**TPD**	**Description**	**TPD**
Green Liquor	876	White Liquor Clarifier Overflow (White Liquor)	***653***
LP Steam for Maintaining Temp	10	White Liquor Clarifier Underflow (Lime Mud)	282
Quick Lime of 80 % Purity	54	Rejects from Slaker (Grits)	5
Total	**940**	**Total**	**940**

Section: Lime Mud Washer-1

Inputs (TPD)		**Outputs (TPD)**	
Description	**TPD**	**Description**	**TPD**
White Liquor Clarifier Underflow	282	Mud Washer-1 Overflow (Weak White Liquor)	915
Mud Washer-2 Overflow for Dilution	875	Mud Washer-1 Underflow	242
Total	**1157**	**Total**	**1157**

Section: Lime Mud Washer-2

Inputs (TPD)		Outputs (TPD)	
Description	**TPD**	**Description**	**TPD**
Mud Washer-1 Underflow	242	Mud Washer-2 Overflow	875
Lime Mud Thickener Filtrate for Dilution	897	Mud Washer-2 Underflow	264
Total	**1139**	**Total**	**1139**

Section: Lime Mud Filter (Disc Filter)

Inputs (TPD)		Outputs (TPD)	
Description	**TPD**	**Description**	**TPD**
Mud Washer-2 Underflow	264	Lime Mud after Thickening	83.5
Black Liquor Secondary Condensate for Dilution	116	Moisture Carryover with Lime Mud @ 50 %	83.5
Black Liquor Secondary Condensate in Spray Showers	684	Lime Mud Thickener Filtrate	897
Total	**1064**	**Total**	**1064**

Section: Recovery Furnace 1 & 2 (Steam Generation)

Input (TPD)		Output (TPD)	
Description	**TPD**	**Description**	**TPD**
LP Steam Primary Condensate from Evaporators	481	Steam Generation from Recovery Boiler-1 @ 16.5 TPH	396
DM/RO Water from Energy Section	633	Steam Generation from Recovery Boiler-2 @ 34.5 TPH	828
LP Steam for Increasing DM/RO Water Temperature	117	Steam Vent Off from Deaerator	7
Fresh Water/Raw Water	1450	Evaporation from Cooling Tower	850
		Cooling Tower Blow Down (To ETP)	300
		Pumps Cooling & Sealing Back water (To ETP)	300
Total	**2681**	**Total**	**2681**

Water & Material Balance: Paper Machine-1

Input		Output	
Description	**TPD**	**Description**	**TPD**
Pulp	109	Paper Produced	**155**
Water With Pulp	2616	Paper Machine Back Water to Silo Tank (Reused)	12579
Chemicals & Additives	46	Water Evaporated From Paper Machine (Inlet Dryness: 42 %)	206
Fresh Water in Chemical Preparation	150	Moisture Carry Over with Paper (Moisture: 5 %)	8
Paper Machine Back Water	12579	Paper Machine Excess Back Water	4141
Fresh Water Used in Showers and Cooling & Sealing System	1589		
Total	**17089**	**Total**	**17089**

Water & Material Balance: Paper Machine-2

Input		Output	
Description	**TPD**	**Description**	**TPD**
Pulp	181	Paper Produced	**260**
Water With Pulp	4344	Paper Machine Back Water to Silo Tank (Reused)	21116
Chemical & Additives	79	Water Evaporated From Paper Machine (Inlet Dryness: 41 %)	374
Fresh Water in Chemical Preparation	280	Moisture Carry Over with Paper (Moisture: 5 %)	13
Paper Machine Back Water	21116	Paper Machine Excess Back Water	7037
Fresh Water Used in Showers and Cooling & Sealing System	2800		
Total	**28800**	**Total**	**28800**

Water Balance: ClO_2 Plant

Input		Output	
Description	**TPD**	**Description**	**TPD**
Sodium Chlorate	9.57	ClO_2	6.0
H_2SO_4	4.71	Water carryover with ClO_2 Solution	646
Other Chemicals	1.08	Na_2SO_4	5.58
Fresh Water	642		
Total	**657.58**	**Total**	**657.58**

Water Balance: Energy (Cogeneration Power Boiler 2 & 3)

Input		Output	
Description	**m^3/day**	**Description**	**m^3/day**
Raw Water/Fresh Water	3900	RO/DM Water	1585
Fresh Water as Hot Water from Sulphuric Acid Plant (SAP)	240	RO/DM Plant Rejects	730
		Boiler Blow Down	95
		Cooling Tower Evaporation	1280
		Cooling Tower Blow Down	250
		Pumps Gland Cooling	50
		Ash Cooling System	100
		Ash Compressor Cooling	50
Total	**4140**	**Total**	**4140**

Annex B - Effluents and Emissions Guidelines / Resource Use Benchmarks

Table 1 (a)—Effluent Guidelines for Pulp and Paper Facilities—Bleached Kraft Pulp, Integrated

Parameter	Units	Guideline
Flow [a]	m^3/ADt	50
pH		6 – 9
TSS	kg/ADt	1.5
COD	kg/ADt	20
BOD_5	kg/ADt	1
AOX	kg/ADt	0.25
Total N	kg/ADt	0.2[b]
Total P	kg/ADt	0.03

Table 1 (b)—Effluent Guidelines for Pulp and Paper Facilities—Unbleached Kraft Pulp, Integrated

Parameter	Units	Guideline
Flow [a]	m^3/ADt	25
pH		6 – 9
TSS	kg/ADt	1.0
COD	kg/ADt	10
BOD_5	kg/ADt	0.7
Total N	kg/ADt	0.2
Total P	kg/ADt	0.02

Table 1 (c)—Effluent Guidelines for Sulfite Pulp and Paper Facilities—Sulfite Pulp, Integrated and Non-Integrated

Parameter	Units	Guideline
Flow [a]	m^3/ADt	55[d]
pH		6 – 9
TSS	kg/ADt	2.0
COD	kg/ADt	30[e]
BOD_5	kg/ADt	2.0
AOX	kg/ADt	0.005
Total N	kg/ADt	0.5
Total P	kg/ADt	0.05

Table 1 (d)—Effluent Guidelines for CTMP Facilities

Parameter	Units	Guideline
Flow [a]	m^3/ADt	20
pH		6 – 9
TSS	kg/ADt	1.0
COD	kg/ADt	5
BOD_5	kg/ADt	1.0
Total N	kg/ADt	0.2
Total P	kg/ADt	0.01

Annexure -IV

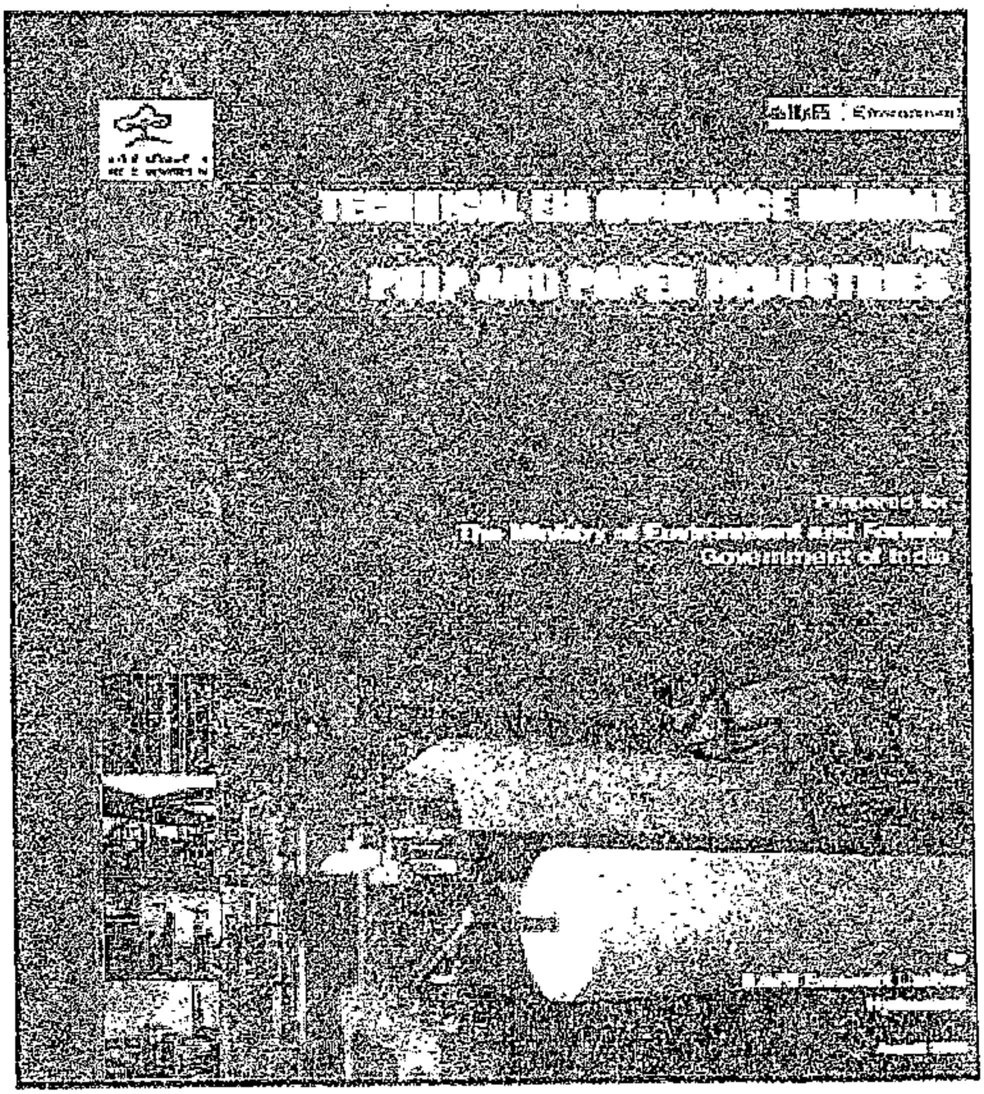


Table 3-28: Product Wise sp. Energy and Water Consumption during Papermaking in Indian Paper Mills

Product wise average	NP	WP	NP+WP	Industrial papers	WP + Industrial papers+ Specialty
Avg. sp energy consumption (GJ/ BDMT)	9.2	11.2	11.5	12.5	13.5
Avg. sp water consumption (m3/ BDMT)	33.0	78.0	59.0	43.0	81.0

Table 3-29: Specific Water Consumption (m^3/ BDMT) in Indian mills   Basic Raw Material

	Wood Based	Non wood based	Waste paper based
a. Indian avg	153	203	39
b. Indian best	103	115	25
c. Global best	37	35	5

Table 3-30: Specific Water Consumption with Various Pulping Technologies in Indian Paper Mills (m^3/BDMT)

	Kraft	RGP	CMP + CP	WP	WP+Chem
a. Indian average	152	173	139	105	129
b. Indian best	131	150	105	59	25
c. Global best	41.8	36.3	25.1	6	21.2

Table 3-31: Sp Water Consumption in Indian Mills with Different Product Profiles (m3/ BDMT)

	WP+N	Industrial	WP	NP	All3
a. Indian average	139	101.5	165	73	176
b. Indian best	115.5	27.65	59.9	57	123.6
c. Global best	29.1	33.2	35	11.3	35.5

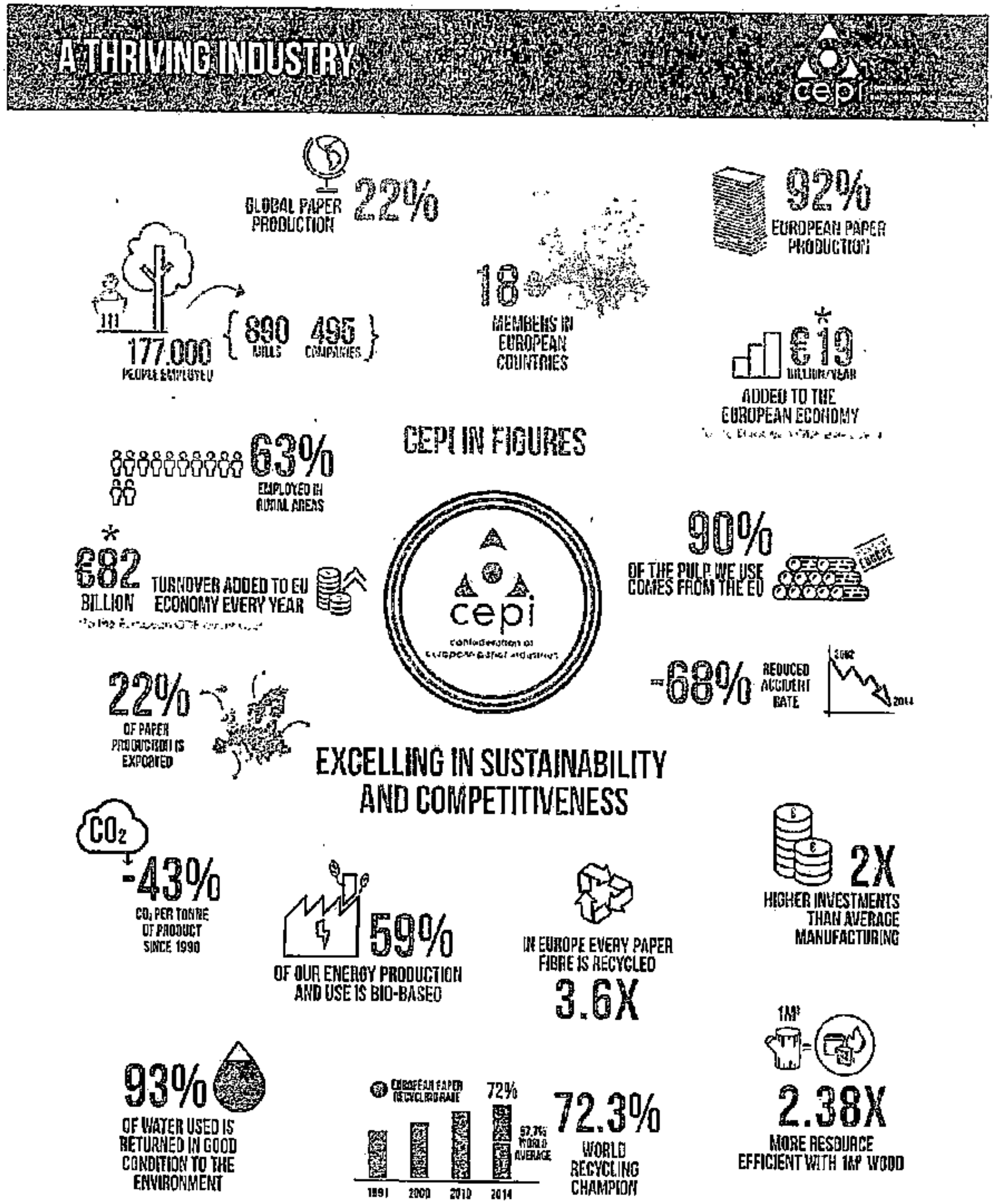
Table 3-32: Water Closure in Indian Paper Mills using Different Raw Materials (%)

	Integrated based on				
	Wood	Bagasse	Wastepaper	WB based	RGP
a. Closure of process water cycle	56	83	35	72	39
b. Closure of DM water cycle	51	53	29	33	24
c. Closure of overall water cycle	55	62	39	72	38

cepi confederation of european paper industries

Annexure V

SUSTAINABILITY REPORT



CONTACT PERSONS

Jori Ringman
Deputy Director General

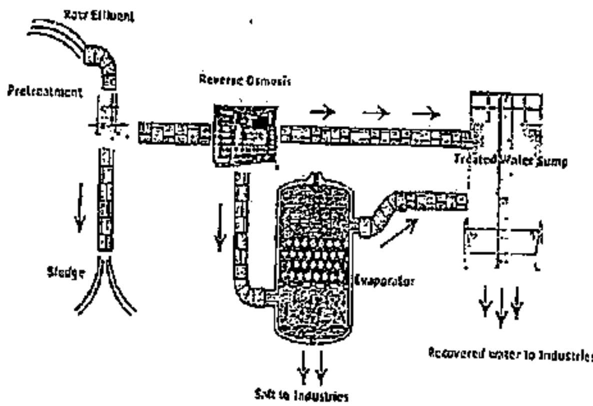
Ben Alexander Kennard
Communications Manager

DATA QUALITY

We pride ourselves in ensuring that our statistics are third-party quality assured. Deloitte has issued a limited assurance statement verifying the quality of the data we collect.

Annexure VI

GUIDELINES
ON
TECHNO – ECONOMIC FEASIBILITY OF IMPLEMENTATION OF ZERO LIQUID DISCHARGE (ZLD) FOR WATER POLLUTING INDUSTRIES



CENTRAL POLLUTION CONTROL BOARD
(Ministry of Environment, Forests & Climate Change)
'Parivesh Bhawan', East Arjun Nagar, Delhi- 110 032

JANUARY 2015

ZERO LIQUID DISCHARGE (ZLD) IN PULP AND PAPER INDUSTRY

1. Pulp and paper industry, worldwide, has been exploring the ZLD concept over the last two decades and has however, not been able to identify a technically feasible, and sustainable, technology to achieve ZLD. The two possible options which have been explored are:

   a. Close up all process water loops by total recycling inside a process sequence or into a different process sequence within the mill.
   b. Treat the effluent in a stand-alone facility to render it suitable for process reuse & volume reduction.

   Closing up the process water loops by extensive recycling has been tried out in different combinations and found to be impracticable, even in the short term, on account of uncontrollable build-up of chlorides, salts and non-product elements in the system; deterioration in product quality; reduced effectiveness of process chemicals; and scaling and corrosion of machinery leading to breakdowns.

2. An ideal stand-alone facility would require conventional wastewater treatment (primary, secondary and tertiary) to reduce the suspended solids and organic loads, followed by a quaternary treatment (typically, multi-stage reverse osmosis (RO) sequences) to maximise recovery of reusable process water and reduce the volumes requiring subsequent treatment such as evaporation, crystallisation and environmentally acceptable management and/or disposal of solids.

3. **Techno feasibility of ZLD:**

   For the present, Zero Liquid Discharge is, techno-economically, not feasible for most mill categories. No country has, therefore, imposed a ZLD condition for the paper industry.

   The current state of art technology routes to achieving ZLD, have the following issues:

   - Sustained 24×7 operation is not dependable.
   - Life cycle costs of ZLD enabling systems are estimated to be too high to be sustained by the economics governing the industry.
   - Concentrated mixed salts, or brine, and the mother liquor will constitute unacceptable cross-media environmental impacts.
   - Available technologies are either power-intensive or steam intensive, or both. Since steam and power have to be generated on site, emissions to air

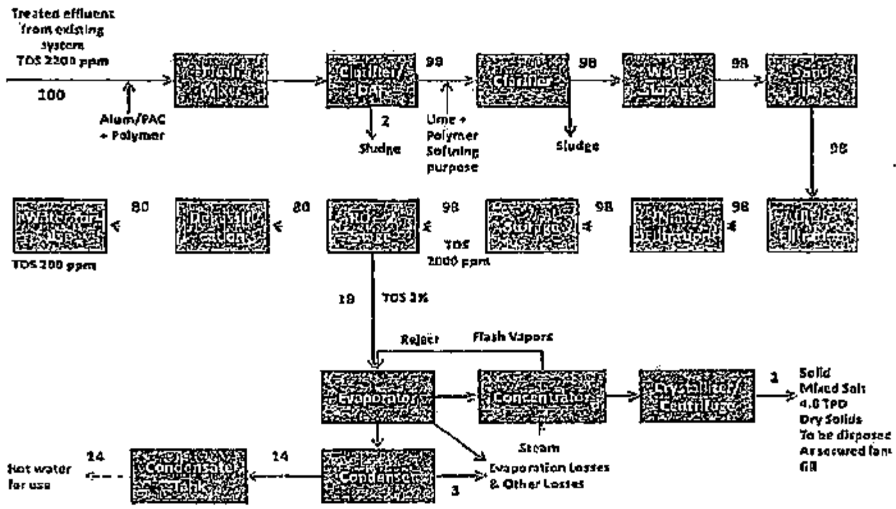
(boiler stacks) and land (boiler ash) will add to the cross-media impacts, besides worsening the carbon foot print of the mill.

4. Economic Feasibility of ZLD:

A typical suggested flow diagram of ideal standalone effluent treatment facility could be as under:

ZLD Concept for Pulp & Paper Mills

Suggested Process Flow (Made on Mass Basis)



Estimated Cost for 100 m3/hr Treated Effluent

Particulars	Unit	Value
Effluent Volume	m^3/hr	100
RO Treatment output	m^3/hr	80
RO Reject feed for evaporation & crystallization	m^3/hr	20
Capital Cost		
RO Plant for 100 m3/hr capacity	Rs.Cr	5.0

Evaporator, Crystallizer & Centrifuge	Rs.Cr	19.0
Civil work pipelines etc.	Rs.Cr	1.0
Total Cost	Rs.Cr	25.0

Investment & Operating Costs

Particulars	Units	Case I
Mill Capacity	TPD	100
Effluent Volume	M^3/day	4000
Capital cost for RO & Evaporation	Rs.Cr	45
Power Requirement for ZLD	MWH	1.0
Capital cost for Power Plant	Rs.Cr.	4.0
Total Capital Cost	Rs.Cr.	49
Operating Cost (@127 Rs/M3)	Rs/Mt paper	5000
Interest Cost (@10%)	Rs/Mt paper	1342
Total Operating Cost	Rs/Mt paper	6342
Annual Operating Cost	Rs.Cr.	23.0

The investment and operative cost based on the suggested flow sheet, for 100 MT per day capacity paper mill has been estimated as above. Post-Charter scenario after implementation of CPCB's proposed Charter was assumed and discharge volume as per the Charter's stringent norms was considered for calculations. For a 100 tpd paper production the additional cost for ZLD has been estimated to be more than Rs 6,342 per tonne of paper. These estimates are very conservative due to the fact that current water consumption level is two times of the norms as proposed under the CPCB's Charter. Huge investment, and implementation time, would be required to reduce the current level of water consumption, and wastewater discharge, to the Charter norms. If cost of Charter implementation is also included, the operative cost of ZLD would be much higher. Further, if the same system is used for small mills (less than 100 tpd) the operative cost will be higher due to lack of economics of scale.

CAPEX & OPEX costs of potential ZLD solutions appear to be prohibitive and unviable. The implementation of ZLD concept through standalone effluent treatment facility would render the mills unviable to operate.

5.0 Road map:

Ideal way is to optimize recycling by process technology optimization to minimize the pollution load at source. The proposed 'Charter for Water Recycling & Pollution Prevention in Pulp & Paper Industry' is based on DAT (European Union's BREF Document yet to be mandated) and has included all the aspects for pollution reduction, which is the accepted principle of pollution control globally. Thus the implementation of charter should be the first step and further control should be through continuous infusion of state of the art production technology and pollution abatement techniques. A concept like ZLD can only be implemented through a long term planning and R&D exercises. Implementation of ZLD would need vast changes in the process of production, which cannot be carried out at this first instance.

The most progressive way forward would be to:

a. Notify, and firmly enforce, the proposed CPCB's 'Charter on Water Recycling and Pollution Prevention in Pulp & Paper Industry' since it will:

   i. raise the effluent related environmental performance of Indian pulp & paper industry in general, and the industry in the Ganges River Basin in particular, comparable to the world's best mandated practices.
   ii. reduce the Ganges River Basin Paper Industry's effluent discharges, and hence the water-borne pollution loads, by more than 50%.
   iii. would make the pursuit of ZLD development options more manageable and economically meaningful on account of the reduction in effluent generation volumes

b. Establish full scale ZLD pilot plants (with entire range of unit operations up to solids handling) at versatile host mills and undertake real-time operations to determine:
   i. Extent of water recovery possible
   ii. Sustainability of 24x7 operations over long periods
   iii. O&M costs
   iv. Upstream changes required
   v. Cross-media environmental impacts

   Ideally at least three such pilot plant facilities would be required, one each, for RCF mills producing brown grades, for RCF mills producing white grades and for fully integrated pulp and paper mills. Enabling Government incentives would help to jump start such pilot plant and related R&D efforts.

Since the ZLD concept and its technology development worldwide is a "work in progress", it should be periodically reviewed, perhaps midway during the Charter implementation, to introduce additional and appropriate regulatory initiatives.

****

BEFORE THE HON'BLE NATIONAL GREEN TRIBUNAL,

Principal Bench, New Delhi

Original Application No. 682/2019

Beant Singh Bajwa, President,

National Anti-Corruption Council Applicant

Versus

State of Punjab Respondent

Index

S. No.	Particulars	Page No.
1.	**Status Report** in compliance of order dated 08.02.2022 in OA No. 682/2019, Beant Singh Bajwa, President, National Anti-Corruption Council Vs. State of Punjab.	
2.	**Annexure-1:** The notified effluent standards for discharge from various industrial sectors under Environment (Protection) Rules, 1986.	
3.	**Annexure-2:** A copy of the minutes of the meeting to review the compliance of Hon'ble NGT order dated 08.02.2022.	
4.	**Annexure-3:** A copy of Hon'ble NGT order dated 08.02.2022.	

(Kamlesh Singh)
Scientist E
Central Pollution Control Board
Delhi-110032

Date: 01.02.2023
Place: Delhi

Status report in compliance of Hon'ble NGT order dated 08.02.2022

In the matter of

Beant Singh Bajwa, President, National Anti-Corruption Council

Versus

State of Punjab
(NGT order dated 08.02.2022 in O.A No. 682 /2019)

By

Ministry of Environment, Forest and Climate Change, New Delhi
Central Pollution Control Board, Delhi

November 2022

Status report in compliance of Hon’ble NGT order dated 08.02.2022

In the matter of

Beant Singh Bajwa, President, National Anti-Corruption Council Versus State of Punjab

(NGT order dated 08.02.2022 in O.A No. 682 /2019)

1.0 Background

In the matter of Beant Singh Bajwa, President, National Anti-Corruption Council (Applicant) Vs. State of Punjab (Respondent) (O.A. No 682/2019) before Hon’ble National Green Tribunal (NGT); the matter has been earlier considered inter alia on 04.12.2019, 24.6.2020 and 29.07.2021 before Hon'ble NGT Principle bench, New Delhi for remedial action against violation of environmental norms by Trident Factory, Dhanaula, Mansa Road, Barnala, Punjab.

Following the report filed by the joint Committee of Central Pollution Control Board (“CPCB”), Punjab SPCB, and District Magistrate, Barnala on 10.11.2021 giving the status of compliance with reference to the earlier report and a report filed by State SPCB dated 10.11.2021, the Hon'ble NGT vide order dated 08.02.2022, apart from direction to SPCB also passed the following direction for MoEF&CC & CPCB:

- *Given the understanding of the concept of the ZLD, the water recovered has to be used in the process itself and no waste water is discharged in recipient environment. This has to be clarified and affirmed by State PCB and separately by CPCB and MoEF&CC for pan India application.*

- *We also direct that CPCB and MoEF&CC through the CPCB to file separate status report on the status of compliance of ZLD with reference to the other categories of industries particularly for distilleries, textile, pulp and paper, pharmaceutical etc . viz-a-viz with reference to standards notified and implications of permitting for disposal of effluents on land, posing serious threat to soil and groundwater in long run, by 15.11.2022.*

- *MoEF&CC & CPCB need to resolve the issue how the pp will secure compliance with ZLD condition. Huge quantity of discharge of treated effluent on land for long time is bound to cause damage to the soil as well as groundwater.*

In this context, in compliance to the said Hon’ble NGT order, CPCB issued letters dated 19.04.2022 and subsequently multiple reminder letters issued to all SPCBs/PCCs to provide the status (as on date) of ZLD based industry in their State along with other relevant inputs for ensuring the timely compliance. In the meantime, CPCB also examined the various aspects of this matter keeping in the mind of above said order for the preparation of this status report.

2.0 Zero Liquid Discharge (ZLD)

The Zero Liquid Discharge (ZLD) concept can be implemented through a long-term planning and research and Development (R&D) exercises. The implementation of ZLD concept would require vast changes in the process of production, which cannot be carried out at this first instance. Adopting ZLD practices may not be feasible in many cases in view of techno-economic reason. The conventional ZLD system involves four stages (i) pre-treatment (ii) pre-concentration (iii) evaporation (iv) crystallization.

2.1 Definition

Zero Liquid discharge (ZLD) implies that the industries are not discharging any effluent, either on land or in the water body or at any other place i.e recycling the same in the process entirely without releasing any effluent (treated/untreated) into the environment.

The ZLD may be defined as '*The entire quantity of effluent is treated to recover water and recovered water is reused in process and/or utilities, and only solids are disposed off (or reused, if possible) in environmentally sound manner. Reuse of treated effluent for horticulture or agriculture purposes will be considered as discharge on land and not as means to achieve ZLD. Similarly, effluent from individual industries being sent to CETP for treatment will not be considered as ZLD.*

2.2 Clarification sought on the concept/definition of ZLD by SPCBs/PCCs.

CPCB asked all SPCBs/PCCs vide letter dated 19.04.2022 & subsequent reminders to remaining SPCBs/PCCs to submit the views/clarification on the ZLD definition along with other information. CPCB examined the reply of various SPCBs/PCCs & found that views/clarification on ZLD definition by SPCB are more or less same with the said definition of ZLD. However, three SPCBs i.e. Madhya Pradesh SPCB, Uttrakhand SPCB and Chhattisgarh SPCB has permitted gardening /horticulture of treated effluent under ZLD condition in their Consent to Operate (CTO) which is not as per the concept of the ZLD.

CPCB has asked Madhya Pradesh PCB (MPPCB) vide letter dated 12.10.2022 to review the ZLD concept considering that under ZLD no wastewater shall be discharged in recipient environment & reuse of treated effluent for horticulture or agriculture purpose will be considered as discharge on land and accordingly modify the CTO to ZLD based industries.

3.0 Existing Notified Environmental Standards of industries & status of sector-wise implementation of ZLD

The environmental standards for various categories of industries have been notified under the Environment (Protection) Rules, 1986 by the Ministry of Environment, Forest & Climate Change (MoEF&CC).

The notified effluent standards for discharge from various industrial sectors under Environment (Protection) Rules, 1986 is annexed at **Annexure-1**. The notified standards have prescribed discharged standards for various industrial sectors, however, the ZLD has not been prescribed and notified under the Environment (Protection) Rules, 1986. The industrial sector such as textile, pulp & paper, Sugar, Pharmaceuticals, Distillery and tanneries has been given discharge standard under the E(P)Rules, 1986. However, in case of distillery industry falling under the Ganga basin, the distilleries are mandatorily required to achieve ZLD as per the directions of CPCB.

The MoEF&CC and CPCB has not made ZLD mandatory for the industrial sectors except Distilleries located in Ganga basin vide CPCB direction dated 07.12.2015. At present, the Distillery industries are under obligation of mandatory ZLD condition falling in Ganga basin. It is to inform that other than Ganga basin, most of the SPCBs/PCCs have issued Consent for the ZLD in the distillery sector. As per the available information, the Ferti-irrigation as well as one-time land application of distillery effluent has not been permitted by the SPCBs/PCCs considering its long term impact on the soil and groundwater.

In reference to other categories of industries like Pulp & paper, Sugar, Textile, Pharmaceutical w.r.t notified standard, the said sectors are allowed for discharge of their treated effluent after meeting the prescribed standards into inland water body or on land subject to certain conditions as prescribed under E(P)Rules / Consent to operate (CTO).

It is also to submit that as per the section 3 subsection (2) of the Environment (Protection) Rules, 1986, SPCBs can specify more stringent standard in respect of any specific industry, operation, or process depending upon the quality of the recipient system and after recording reasons therefore in writing.

3.1 Implementation of ZLD by various industries /Existing status of ZLD

The increase in urbanization and industrialization has resulted in high demand of freshwater. Freshwater scarcity has become the most recent challenge of our time and which need to be utilized in a most sustainable manner. Alternative strategies need to be designed for groundwater or freshwater management. One of the strategies is to reuse and recycling of industrial or domestic wastewater. The treatment system needs to be designed for maximum water recovery and minimizing the amount of wastewater generation via reuse and recycling strategies.

Earlier, in consonance with India's National Water Policy, CPCB had drafted a guidelines in the year 2015 (CPCB, Guidelines on Techno-Economic Feasibility of Implementation of Zero Liquid Discharge (ZLD) for Water Polluting Industries, 2015) and circulated among the SPCBs/PCCs for their comments/views, which expected industries to adopt ZLD technologies and to recover as much treated water as possible for reuse by the industry and thereby help conserved freshwater resources. While CPCB intended ZLD to be applied to industries generating wastewater of high COD/BOD load, color, metals, pesticides, toxic/hazardous waste, solvents and high TDS bearing effluents.

Currently the distillery sector has adopted zero liquid discharge (ZLD) concept through concentration/evaporation and drying/incineration/bio-composting system. Many industries such as Pulp & paper (waste paper based excluding writing & printing grade), Textile, Pharmaceutical, Tannery has voluntary adopted the ZLD system / consented by the SPCBs/PCCs.

CPCB has not directed other Industrial sector excluding distillery (Ganga basin only) for achieving the ZLD.

3.1.1 Distillery industry

The molasses based Distilleries generate large volume of high strength effluent called "spent wash", which is one of the recalcitrant effluent having extremely high COD (80,000-1,20,000 mg/l), BOD (40,000-60,000 mg/l), SS, inorganic solids, low pH, strong odour and dark brown colour.

In distillery, disposal of large volume of waste water is a serious concern. Further wastewater characteristic makes it impossible to achieve the prescribed standard including removal of color through conventional technology and without high level of dilution. CPCB has adopted a policy of ZLD in Ganga basin in 2015 which is logical evolution of zero spent-wash discharge specified under CREP action plan in 2003.

Technologies available/adopted for achieving ZLD in distillery are, namely, (i) Anaerobic digestion (ii) Reverse Osmosis (RO) (iii) Multiple effect evaporation (MEE) followed by drying /incineration of concentrated spent-wash through (i) Spray dryer / Rotary dryer (ii) Slop fired boiler. The bio-composting of concentrated spent wash is also adopted by various distilleries.

The suggested technological options for achieving ZLD in Ganga basin industries include either of the two routes:

(a) R.O & MEE or MEE only followed by Bio-composting Or

Evaporation – Concentration using appropriate tech. such as MEE followed by Incineration boiler.

(b) Advanced process technologies (cont. fermentation, multi pressure distillation, integrated evaporation etc.) for reduction of spent wash to 6-8 KL/KL followed by evaporation-concentration and incineration using tech. such as MEE & Incineration boiler.

The Ministry of Environment, Forest & Climate Change (MoEF&CC) received a representation from Uttar Pradesh Sugar Mills Association (UPSMA) on 09.06.2021 with a request to grant regulatory permission for the use distillery spent-wash in Agriculture. MoEF&CC on the basis of report of the Committee comprising officials of MoEF&CC,

Ministry of Agriculture & CPCB informed to the UPSMA that any sort of land application of spent-wash having COD, BOD & salt load in liquid form shall not be considered.

3.1.2 Pulp and Paper industry

In India, the pulp and paper is manufactured from diverse raw materials such as (i) Wood, (ii) Agro-residues (bagasse/wheat straw etc.) and (ii) waste paper/recycled fiber/RCF.

The Pulp and Paper industry, worldwide, has been exploring the ZLD concept over the last two decades and has however not been able to identify a technically feasible and sustainable, technology to achieve ZLD. In India, ZLD has not been adopted by any Wood and Agro-based pulp & paper mills due to the involvement of huge cost. However, Zero Liquid Discharge (ZLD) system has been adopted by several Recycle fiber /wastepaper-based pulp & paper mills producing packaging grade paper & paperboards and claims to be reusing and recycling 100% wastewater within the process.

At the present, Zero Liquid Discharge is, techno-economically, not feasible for the Wood / Agriculture residue based pulp and paper mills.

3.1.3 Pharmaceutical industry

As per the notified effluent discharge standard prescribed under Environment (Protection) Rules, 1986, the discharge standard is applicable to all mode of discharges except to CETP.

Many pharmaceutical industries have adopted the ZLD system and consented by the respective SPCBs. As per the information received from SPCBs/PCCs about 620 Pharma Units have been issued consent for achieving ZLD.

3.1.4 Textile industry

As per the notified standard prescribed under Environment (Protection) Rules, 1986, the treated effluent of textile industries is allowed to be discharged in the ambient environment only after exhausting options for reuse in industrial process / irrigation in order to minimise freshwater usage.

Several Textile industries has adopted ZLD system and accordingly SPCBs has issued Consent for the ZLD. As per the information received from SPCBs/PCCs about 1754 textile mills have been issued consent for achieving ZLD.

3.1.5 Sugar industry

Sugar sector is the second largest agro based sector in India. Sugar mills are seasonal industries, thus ETPs are not operated in off season/non-crushing season. Large quantity of water is consumed and wastewater is generated in this sector. The final treated effluent discharge has been restricted to 200 lit/T of cane crushed.

The Sugar industries are permitted to use their treated effluent for irrigation purpose after meeting the effluent discharge standard notified under E(P)Rules, 1986. The Treated effluent Irrigation protocol and waste water conservation or waste water management in Sugar industries has been prescribed in the notified discharge standard under E(P)Rules, 1986 and given below:

(i) Loading rates for different soil textures

S.No	Soil Texture	Loading rate in m3 /Ha/Day
1.	Sandy	225 to 280
2.	Sandy loam	170 to 225
3.	Loam	110 to 170
4.	Clay loam	55 to 110
5.	Clay	35 to 55

(ii) Waste water conservation and pollution control management

1) Establishment of cooling arrangement and polishing tank for recycling the excess condensate water to process or utilities or allied units.
2) Effluent Treatment Plant to be stabilized one month prior to the start of the crushing season and continue to operate one month after the crushing season.
3) During no demand period for irrigation, the treated effluent to be stored in a seepage proof lined pond having 15 days holding capacity only.
4) Flow meter to be installed in all water abstraction points and usage of fresh water to be minimized.

3.1.6 Tanneries

As per the notified standard prescribed under Environment (Protection) Rules, 1986, the treated effluent of textile industries is allowed to be discharged in the ambient environment only after exhausting options for reuse in industrial process / irrigation in order to minimize freshwater usage.

Tannery effluent contains TDS in concentration several times higher than this prescribed limit which is contributed by the common salt used for preservation of hides and skins as well as by the inorganic salts and chemicals used in the tanning process. The conventional treatment methods used for effluent treatment are largely aimed to treat organic matter and do not help in reduction of inorganic TDS due to inorganic constituents. Therefore, tanneries clusters are required to adopt extra measures to meet the CETP effluent standard for TDS.

Several Tanneries has adopted ZLD system and accordingly SPCBs has issued Consent for the ZLD. As per the information received from SPCBs/PCCs about 463 Tanneries have been issued consent for ZLD condition.

Annexure-1

S. No.	Industries	Parameters	Discharge Standards (all are in mg/L except pH & wastewater discharge limit)
1.	**Sugar**	pH	5.5-8.5
		TSS	100 (for disposal of land) 30 (for disposal in surface waters)
		BOD	100 (for disposal on land) 30 (for disposal in surface waters)
		Oil & Greece(O&G)	10
		TDS	2100
		Final wastewater discharge limit	200 litre per tonne of cane crushed
	Final treated effluent discharge restricted to 100 litre / tonne of cane crushed and Waste water from spray pond overflow or cooling tower blow-down to be restricted to 100 litre / tonne of cane crushed and only single outlet point from unit is allowed.		
2.	**FERMENTATION INDUSTRY** (DISTILLERIES, MALTRIES AND BREWERIES)	Parameters	Concentration in the effluents not to exceed milligramme per litre (except for pH and colour & odour)
		pH, Colour & Odour	5.5 – 9.0 All efforts should be made to remove colour and unpleasant odour as far as practicable.
		TSS	100
		BOD	100 (for disposal on land or irrigation) 30 (inland surface waters or river/ streams)
3.	**LARGE PULP & PAPER** News print/ Rayon grade plants of **(Capacity above 24000MT/annum**	Parameter	Concentration in mg/l except pH , AOX and SAR
		pH	7.0-8.5
		BOD	30
		COD	350
		TSS	50
		AOX	1.0 kg/ton of product
		Flow (Total Waste Water Discharge) (i)Large Pulp & Paper ii)Large Rayon Grade Newsprint	 200 Cum/Ton of Paper produced 150 Cum/Ton of Paper produced
	SMALL PULP AND PAPER , Paper Plant of Capacity upto 24000 MT/Annum	pH	5.5-9.0
		Suspended Solids	100 (Disposal on land & Discharge into inland surface water)
		BOD	30 (Discharge into inland surface water) 100(Disposal on land)
		SAR	26
		AOX	2.00 kg/ton of paper produced
		Total waste water discharge	

S. No.	Industries	Parameters	**Discharge Standards** (all are in mg/L except pH & wastewater discharge limit)
		*Agrobased The agro based mills to be established from January, 1992 will meet the standards of 150 cum/Ton of paper produced.	200 cum/Ton of paper produced
		Waste paper based The waste-paper mills to be established from January, 1992 will meet the standards of 50 cum/Tom of paper produced.	75 cum/Ton of paper produced
4.	**Bulk Drug and Formulation** (Pharmaceutical)	Compulsory parameter	Limiting value for concentration (in mg/l except for pH and Bio assay)
		pH	6.5-8.5
		BOD	30
		COD	250
		TSS	100
		O&G	10
		Ammonical Nitrogen	100
		Bio - Assay Test	90% Survival of Fish after first 96 hours in 100% effluent
		The standard is applicable to all discharges except to CETP.	
5.	**All Integrated textile units**, units of Cotton / Woollen / Carpets / Polyester, Units having Printing / Dyeing / Bleaching process or manufacturing and Garment units	Parameters	Standard (applicable for all modes of disposal*)
		pH	6.5 to 8.5
		TSS	100
		Colour, P.C.U (Platinum Cobalt Units)	150
		BOD	30
		COD	250
		O&G	10
		TDS	2100**
		SAR	26**
	➢ In case of direct disposal into rivers and lakes, the Central Pollution Control Board (CPCB) or State Pollution Control Boards / Pollution Control Committees (SPCBs / PCCs) may specify more stringent standards depending upon the quality of the recipient system. ➢ Standards for TDS and SAR shall not be applicable in case of marine disposal through proper marine outfall. ➢ The treated effluent shall be allowed to be discharged in the ambient environment only after exhausting options for reuse in industrial process / irrigation in order to minimize freshwater usage.		

<table>
<tr><th>S. No.</th><th>Industries</th><th>Parameters</th><th>Discharge Standards (all are in mg/L except pH & wastewater discharge limit)</th></tr>
<tr><td></td><td colspan="3">➢ Any textile unit attached with the Common Effluent Treatment Plant (CETP) shall achieve the inlet and treated effluent quality standards as specified in serial number 55 of Schedule-I to the Environment (Protection) Rules, 1986 and shall also be jointly and severally responsible for ensuring compliance
➢ The standalone large scale units shall meet the values specified above; however, CPCB or SPCBs / PCCs with the approval of CPCB, may mandate Zero Liquid Discharge in Large scale units in environmentally sensitive / critical areas.
➢ The TDS value with respect to treated effluent shall be 2100 mg/litre; however, in case where TDS in intake water is above 1100 mg/litre, a maximum contribution up to 1000 mg/litre shall be permitted provided the maximum value of 3100 mg/litre is not exceeded in the treated effluent."</td></tr>
<tr><td rowspan="11">6.</td><td rowspan="10">TANNERY</td><td>Parameter</td><td>Standards
(applicable for all modes of disposal*)</td></tr>
<tr><td>pH</td><td>6-9</td></tr>
<tr><td>BOD</td><td>20</td></tr>
<tr><td>COD</td><td>250</td></tr>
<tr><td>TSS</td><td>50</td></tr>
<tr><td>TDS</td><td>2100**</td></tr>
<tr><td>Sulphides (as S)</td><td>2.0</td></tr>
<tr><td>Total Chromium (as Cr)</td><td>2.0</td></tr>
<tr><td>Hexavalent Chromium
(as Cr +6)</td><td>0.1</td></tr>
<tr><td>Oils and Grease</td><td>10</td></tr>
<tr><td colspan="3">• *In case of direct disposal into rivers and lakes, the Central Pollution Control Board (CPCB) or State Pollution Control Boards / Pollution Control Committees (SPCBs / PCCs) may specify more stringent standards depending upon the quality of the recipient system.
• *Standards for TDS shall not be applicable in case of marine disposal through proper marine outfall.
• **TDS limit with respect to treated effluent shall be 2100 mg/l; however, in case where TDS in intake water is above 1100 mg/l, a maximum contribution up to 1000 mg/l shall be permitted provided the maximum limit of 3100 mg/l is not exceeded in the treated effluent.
• The treated effluent shall be allowed to be discharged in the ambient environment only after exhausting options for reuse in industrial process / irrigation in order to minimize freshwater usage.
• The standalone units shall meet prescribed discharge norms; however, SPCB / PCC shall mandate recycle / reuse of the treated water in water scarce / environmentally sensitive / critical areas.
• In case of discharge of treated effluent on land for irrigation, the impact on soil and groundwater quality shall be monitored twice a year (pre- and post- monsoon) by the tannery unit</td></tr>
</table>

केन्द्रीय प्रदूषण नियंत्रण बोर्ड
CENTRAL POLLUTION CONTROL BOARD
(पर्यावरण एवं वन मंत्रालय, भारत सरकार)
(MINISTRY OF ENVIRONMENT & FORESTS, GOVT. OF INDIA)

B-400/PCI-III/2014-15

19-01-2015

To

The Member Secretary
All State PCBs/PCCs/Zonal officers

Sub: Guidelines on Techno-Economic Feasibility of implementation of Zero Liquid Discharge (ZLD) for Water Polluting Industries. reg.

Sir,

Implementation of Zero Liquid Discharge (ZLD) in all types of industrial sectors is an important issue and in many sectors, technology wise it is possible and can be achieved. In many cases, Hon'ble Courts/ Tribunal are also seeking opinion from regulators about the feasibility and possibilities of its total implementation. Technically in many parts of the country and in many sectors it is being practiced/demonstrated successfully, though the economic aspects are in question.

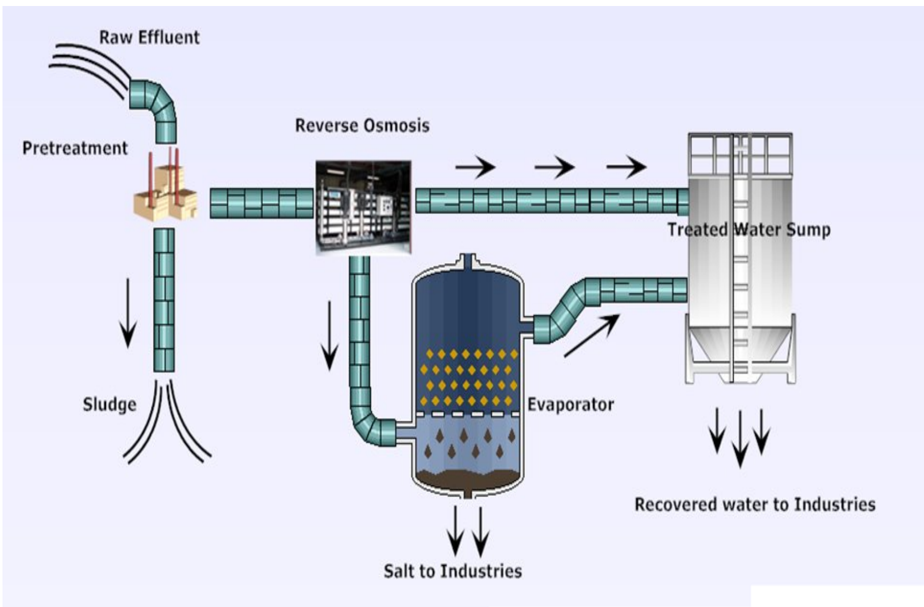
In view of this Central Pollution Control Board is in the process of preparing 'Guidelines on Techno-Economic Feasibility of implementation of Zero Liquid Discharge (ZLD) for Water Polluting Industries'. It is requested that the draft may be reviewed and the consolidated suggestions/modifications may be forwarded to this office by 27-01-2015 to email adaba.cpcb@nic.in

Yours faithfully,

Encl: as above

(A.B. Akolkar)
Member Secretary 19.1

GUIDELINES
ON
TECHNO – ECONOMIC FEASIBILITY OF IMPLEMENTATION OF ZERO LIQUID DISCHARGE (ZLD) FOR WATER POLLUTING INDUSTRIES



CENTRAL POLLUTION CONTROL BOARD
(Ministry of Environment, Forests & Climate Change)
'Parivesh Bhawan', East Arjun Nagar, Delhi- 110 032
JANUARY 2015

GUIDELINES ON TECHNO-ECONOMIC FEASIBILITY OF IMPLEMENTATION OF ZERO LIQUID DISCHARGE (ZLD) FOR WATER POLLUTING INDUSTRIES

1.0 Introduction

It has been estimated that 501 MLD of industrial effluent is being discharged by water polluting industries through drains of tributaries into River Ganga.

Water polluting industries (GPI), are mainly of industries discharging effluents having BOD load of 500kg/day or having toxic / hazardous chemicals. There are 2535 industries identified in Ganga basin which includes states of Uttarakhand [74] Uttar Pradesh [993], Bihar [40], Jharkhand [94] and West Bengal [147], Delhi [5], Madhya Pradesh [19], Chhattisgarh [26].

The industries have been persuaded to set-up effluent treatment plants & CETPs and operate them to meet with prescribed standards.

2.0 Water Polluting Industries

The industries identified as water polluting industries are: - Sugar, Distilleries, Pulp and Paper, Tanneries, Chemicals, Dyeing and Textiles, Refineries, Food, Dairy and Beverages, Electroplating and others. The water polluting industries discharge their effluent having high organic contents measured in-terms of bio-chemical oxygen demand (BOD), and other toxic constituents like metals, organic and in-organic compounds.

3.0 Effluent Treatment Plants (ETPs)

The systems available of treating industrial effluent are based on Physico-chemical and biological principles. The operation of effluent treatment plants requires technical skill and regular attention so to achieve compliance to standards for 24 hrs x 365 days.

4.0 Standards for Compliance

Standards for compliance have been notified under the Environment Protection Act, 1986. The notified standards permit industries to discharge the effluents only after compliance. However, CPCB and SPCBs / PCCs now, are insisting industries to reduce water consumption and also take measures to not-to-discharge effluents. But, it has been observed that industries are not able to meet all time compliance standards and as a result, rivers like Ganga and its tributaries is carrying high pollution load and it is the dilution available in river water which helps in minimizing pollution load.

5.0 Necessity for Zero Liquid Discharge (ZLD)

After having recognition of problems that many industrial sectors are not able to achieve standards and this ultimately necessitates to work towards Zero Liquid / effluent discharge standard.

6.0 Definition of ZLD

Zero Liquid discharge refers to installation of facilities and system which will enable industrial effluent for absolute recycling of permeate and converting solute (dissolved organic and in-organic compounds/salts) into residue in the solid form by adopting method of concentration and thermal evaporation. ZLD will be recognized and certified based on two broad parameters that is, water consumption versus waste water re-used or recycled (permeate) and corresponding solids recovered (percent total dissolved / suspended solids in effluents).

7.0 Technical needs for ZLD – The guidelines

Adoption of Zero Liquid Discharge system will be applicable to zero-down organic load, recover metals and other constituents. Direct installation of ZLD facilities may have technical constraints to operate specialized system.

Pre-requisite for ZLD accomplishment would need physical and chemical treatment and followed by biological system to remove organic load. The treated effluents can be then subjected for concentration and evaporation. The concentration process as applicable can be adopted at appropriate stage. The concentration method quite often involves the adoption of Reverse Osmosis (RO) and Nano Filtration (NF) methods. The evaporation methods involve incineration/ drying / evaporation of effluent in multi effect evaporators (MEE).

In the process of achieving ZLD, solids recovered and these are to be utilized. However, in case of not used, they will have to be stored. Cost-wise, achieving ZLD will be costly proposition but, now becoming necessity because rivers need to be rejuvenated. A typical cost indicates that a CETP treating 1 MLD of waste water with conventional physico-chemical and biological treatment is around Rs. 3.0 to 4.0 Crores with operation and maintenance cost of Rs. 300-350 per cubic meter (M^3), Whereas, cost of combination of conventional ETP with ZLD facilities costs around Rs. 12.0 to 15.0 Crores per MLD.

Now, the ZLD adoption is becoming essential rather than imposition.

8.0 Application of ZLD in Industries

The significant industrial sectors like Sugar, Distilleries, Tanneries, Pulp & Paper, Textile, Dyeing, and Dairy would need special emphasis for enforcement of ZLD. It is important to mention that in the name of ZLD, no forceful injection into ground water table is to be tried nor utilizing effluents / permeate for irrigation / or horticulture. ZLD would strictly means recycling treated effluent back for re-use in industrial / or domestic purpose but, exclude use / disposed in ambient environment.

ZLD is applicable to industries having high BOD and COD load, colour bearing effluents, having metals, pesticides and other toxic / hazardous constituents.

9.0 Technical Route for Achieving ZLD

ZLD can be achieved by adopting conventional primary, secondary and tertiary effluent treatment and polishing by filtration and using clean water back into process / or domestic use. In some case, Reverse Osmosis, Micro/Nano Filtration and concentrating with Multiple Effect Evaporators (MEE) can be employed. It has been quite often debated that employing ZLD route is energy intensive and having exorbitant cost / financial burden. But, it cannot be denied that in the present circumstances when ground water table is getting depleted and there is diminishing flow in rivers, permitting industries to discharge even treated effluents, does not seems to be environmentally acceptable proposition. However, industries will be at their technical wisdom and expertise to search for better ZLD achieving practice but with a caution that there will stern actions if, on the name of ZLD, un-acceptable practices are adopted.

In some cases, if any industry feels that a given process needs modification, stopped or substituted, they can do so but, in longer run, treated effluents cannot be disposed. It is also to be understood that in absence of ZLD, industry has to meet compliance with standards and the results through on-line effluent monitoring devices will be available with regulatory authorities and also in public domain.

10.0 Adoption of ZLD in Distilleries, Pulp & Paper, Tanneries, Textiles, and CETPs

Many industries which include Distilleries, Pulp & Paper (waste paper pulping), Textiles and Tanneries clusters operating through Common Effluent Treatment Plants (CETPs) have implemented ZLD systems.

CPCB has also carried out consultation with Pulp & Paper and Tanneries and the strategy / guidelines emerged are given in Annexure-I, II, III, IV, V, VI, VII, VIII & IX

11.0 Conclusion and Way Forward

i. The industries having high organic load and other refractory nature of pollutants will be requiring to adopt ZLD system.

ii. ZLD refers to a system which would enable and industry to recover clean water using back into industrial processes or domestic use and not subjecting to be disposed in ambient environment including use in industrial premises.

iii. Industries will have options to select technical system facilitating to achieve ZLD.

iv. Industries are liable to face closures if found violating the prescribed standards and not having installed on-line effluent monitoring devices where data will have to be available with regulatory bodies and also in public domain.

v. Sectors like Pulp & Paper will immediately adopt charter which will facilitate them to reduce pollution load and maximize reduction in water usage / consumption as well as reducing in quantity of effluent disposed. However, such industries shall be subjected to regular vigilance and followed by stern action in case of their non-compliance to the existing stipulated / notified standards.

****

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TC-5418

NABL Scope

Test Report

Issued To:
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Rajamadendravaram Mill,
Sriram Nagar,

Rajamahendravaram-533105
Andhra Pradesh,IND
Ph: Mob:8498092437

Kind Attn:Mr. S.Chandra Murthy

Registration/Report Number: **VLL/VLS/24/18657/002**
Issue Date: 2025-01-29
Your Ref: 13814202
and Date: 2024-12-26
Lab Ref No.: 1906973
LIMS Report No.: 610597(Report su

Customer Provided Details :			
Sample Name:	**Treated Effluent**		
Batch Number:	NA	A.R. Number:	NA
Mfg. Date:	NA	Exp. Date:	NA
Test Required:	As per Attached List		
Other Details if Any:	NA		
Lab Provided Details :			
Sample Received Date:	2024-12-30	Sample Registration Date:	2024-12-31
Analysis Starting Date:	2025-01-01	Analysis Completion Date:	2025-01-16
Submitted Quantity:	5 Ltr Bottle X 1 No		
Sampling Details:	NA		
Method of Testing:	As per APHA 24th Edition and IS 3025-part44 and As per SOP.NO.02/131 Instrument Used Malvern Ma		
Other Details if Any:	NA		

ULR-TC541825000002427F

Chemical
Pollution & Environment

TEST RESULTS

S. No.	Test Parameters	UOM	Requirements	Results
1	Color	Pt/Co units	All efforts should be made to remove colour as far as practicable.	5.0
2	Odour	--	All efforts should be made to remove unpleasant odour as far as practicable.	Dis-Agreeable
3	Total Suspended Solids at 105°C	mg/l	<100	14

Scan the QR code to check the report authenticity

Name and Designation of Authorized Signatory

Dr.Subbareddy Mallampati
Manager - Environment

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TEST RESULTS

S. No.	Test Parameters	UOM	Requirements	Results
4	pH at 25°C	---	5.5-9.0	7.76
5	Temperature	°C	shall not exceed 5°C above the receiving water temperature	25.8
6	Oil and Grease	mg/l	10	2.4
7	Total Residual Chlorine	mg/l	1.0	<0.1
8	Ammonical Nitrogen as N	mg/l	50.0	27.16
9	Total Kjeldahl Nitrogen as NH3	mg/l	100	48.4
10	Free Ammonia as NH3	mg/l	5.0	<1.0
11	Biochemical Oxygen Demand 3 days at 27°C	mg/l	30	15
12	Chemical Oxygen Demand at 150° C	mg/l	250	95
13	Arsenic as As	mg/l	0.2	<0.01
14	Mercury as Hg	mg/l	0.01	<0.001
15	Lead as Pb	mg/l	0.1	0.02
16	Cadmium as Cd	mg/l	2.0	0.01
17	Hexavalent Chromium as Cr+6	mg/l	0.1	<0.02
18	Total Chromium as Cr	mg/l	2.0	0.08
19	Copper as Cu	mg/l	3.0	0.09
20	Zinc as Zn	mg/l	5.0	0.16
21	selenium as Se	mg/l	0.05	<0.01
22	Nickel as Ni	mg/l	3.0	<0.01
23	Cyanide as CN	mg/l	0.2	<0.02
24	Fluoride as F	mg/l	2.0	0.45
25	Dissolved Phosphates as P	mg/l	5.0	3.49
26	Sulphide as S	mg/l	2.0	<1.0

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Lab Ref No.: 1906973
LIMS Report No.: 610597(Report su

TEST RESULTS

S. No.	Test Parameters	UOM	Requirements	Results
27	Phenolic Compounds as C6H5OH	mg/l	1.0	<0.001
28	Manganese as Mn	mg/l	2.0	0.44
29	Iron as Fe	mg/l	3.0	0.57
30	Vanadium as V	mg/l	0.2	0.09
31	Calcium as Ca	%	-	0.01
32	Nitrate Nitrogen	mg/l	10	8.46
33	Magnesium as Mg	%	-	0.001
34	Sodium as Na	%	-	0.04
35	Potassium as K	%	-	0.01
36	Sulphates as SO4	%	-	0.07
37	Silica as SiO2	%	-	<0.001
38	Electrical conductivity	µS/cm	-	3170
39	Sodium absorption ratio	---	-	2.86

Results relate only to the sample tested.

Remarks: This report is superceded to report with Reg No. VLL/VLS/24/18657.002 and lims report bearing no.608110 and reason is additional parameter included.

- END OF THE TEST REPORT -

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Dr.Subbareddy Mallampati
Manager - Environment

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Water & Effluent per Ton of Paper - 2014 - 15							
Products	Paper	Wetlap	Drypulp	Water		Effluent	
	TPM	TPM	TPM	KLM	KL/Ton	KLM	KL/Ton
Apr-14	13,943	3,305	123	10,89,910	63	7,90,455	46
May-14	14,358	1,933	18	11,45,819	70	8,91,409	55
Jun-14	13,508	2,864	80	10,76,319	65	8,71,500	53
Jul-14	7,511	1,921	251	9,05,364	94	5,47,273	57
Aug-14	14,037	3,263	112	11,64,454	67	7,82,773	45
Sep-14	13,812	2,279	173	11,00,182	68	7,97,318	49
Oct-14	14,569	3,003	33	11,26,909	64	7,50,136	43
Nov-14	14,348	2,742	0	10,46,227	61	6,83,682	40
Dec-14	14,887	2,886	0	11,03,864	62	7,81,000	44
Jan-15	13,267	3,074	0	11,05,682	68	8,16,364	50
Feb-15	11,739	1,984	0	9,92,591	72	6,57,455	48
Mar-15	14,253	3,945	0	10,96,955	60	7,66,545	42
Total	**1,60,232**	**33,199**	**790**	**1,29,54,273**		**91,35,910**	
Average					**68**		**48**

Water & Effluent per Ton of Paper - 2024- 25							
Products	Paper	Wetlap	Drypulp	Water		Effluent	
	TPM	TPM	TPM	KLM	KL/Ton	KLM	KL/Ton
May-24	14,024	4,039	276	9,55,617	52.11	8,10,113	44.17
Jun-24	15,385	4,885	16	8,99,288	44.33	7,82,382	38.57
Jul-24	15,476	4,151	17	9,53,094	48.52	8,87,351	45.17
Aug-24	15,486	3,619	355	9,95,217	51.14	8,24,661	42.38
Sep-24	15,322	4,371	0	9,87,744	50.16	8,10,886	41.18
Oct-24	14,807	4,398	0	9,74,642	50.75	8,45,300	44.01
Nov-24	15,376	3,271	0	9,11,710	48.89	7,93,656	42.56
Dec-24	15,115	3,172	0	9,12,475	49.90	8,42,300	46.06
Jan-25	12,757	3,275	0	7,40,439	46.2	6,81,459	42.51
Feb-25							
Mar-25							
Total	**1,33,749**	**35,182**	**664**	**83,30,225**		**72,78,108**	
Average					**49.11**		**42.96**