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An Approach Towards Sustainability by Adopting New Innovative Concepts At M/S Bindals Papers Mills Ltd.

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Abstract: *BPML, established in 2009, produces writing and printing (non-surface sized, SS Maplitho and Copier) grade papers with a capacity of 1.1 Lakh tons per annum with latest technologies in Process for Pulping and Paper making. BPML has always been on a quest to look for state-of-the-art techniques for a greener ecosphere. One of the major advances towards this initiative has been the efforts to reduce water foot print. The organization has realized an innovative approach to reduce Fresh Water consumption by recycling Back Water from individual sections of the mill, adopting 4R methodology i.e. Reduce, Reuse, Recycle and Recover. BPML worked out a systematic plan following three pronged philosophy to achieve their goal of Water Footprint by (a) Reduction of pollution load at source itself; (b) Zero/ minimum effluent discharge from individual sections of the Mills; (c)Up gradation of ETP Plant BPML applied their approach as follows (1) In its First philosophy, BPML has changed their bleaching stage of Extraction which produces maximum pollution load in effluent as BOD, COD& Color has been replaced to Oxidative stage by introducing Oxidative Chemical. (2) In second philosophy, to make each section of the mill as zero/minimum discharge of effluent (a) Pulp Mill & Recovery: Closed all sections, such that the recycled water can be used in the same section rather than fresh water. This was implemented in all sections except the Bleaching section where the first stage bleaching effluent goes to ETP Plant for the treatment. (b) Paper Machine: Fresh water being used in Wire & Press sections replaced with treated Paper Machine white water by installing specially designed DAF followed by Micro Filters to achieve less than 10 ppm in the white water. Also, recovered water from the Centri-Cleaner reject and utilize it as make-up water for the cooling tower. Thus, making the Paper machine as a closed loop. Upgraded the ETP Plant by installing the following (a) Mist Aeration system, in the Aeration tank in addition to fixed Surface Aerators to further strengthen in air supply. (b) DAF, after Secondary Clarifier to meet prescribed norms of BOD, COD, Colour and Suspended solids. To achieve ZLD, a customized RO system has been installed for integrated Pulp & Paper Mill which is under commissioning. The details of their systematic approach have been elaborated in this paper.*

Key words: New Innovative Concepts, Paper industry, Pulp Mill & Recovery

1. Introduction

In Globally, millions of tons of sewage, industrial and agricultural water is discharged in to world waterways. This waste water contaminates fresh water and ecosystem, threatening food security, access to safe drinking and bathing water and being a major health and environmental management challenge. Managing waste water is linked to management of the entire water chain and it is essential that waste water management is taken up as part of integrated management that operates across sectors.

Efficient waste management and disposal is the basis of sustainable development. With increasingly stringent regulations for waterbodies cleanliness norms, the implementation of advanced water treatment is called for. The Zero Liquid Discharge is the ideal solution where wastewater discharge is eliminated by a complete closed loop cycle and environmental regulations are adequately met. Hence, demining the potential applicability of ZLD for water treatment is crucial.

In 2015, regulatory authorities (CPCB) implemented a charter to reduce fresh water consumption / effluent discharge with more stringent norms of effluent discharge. The ultimate aim of this charter was to make Paper Mills as ZLD.

Membrane based technologies for ZLD are a potentially applicable methods that can be utilized. It is applicable for industrial plant effluent treatment, waste water reclamation and industrial recycling applications. Moreover, it is advanced waste water treatment employing newer efficient methods.

Bindals Papers Mills Ltd, Muzaffarnagar, UP, is an integrated Pulp & Paper plant, situated in Western Uttar Pradesh. It has capacity of producing 110000 Tons per annum writing and Printing grade paper with single indigenous Paper Machine. Pulp is produced by using agro waste e.g. Bagasse, wheat straw and farmers grown hard wood and Poplar.

2. Sustainability by New Innovative Concepts

BPML worked out on different concepts and a systematic plan was adopted with three pronged philosophy to achieve the goal of minimizing Water Footprint by 1. Reduction of pollution load at source itself. 2. Zero/ minimum effluent discharge from individual sections of the Mills. 3. Up gradation of ETP Plant.

2.1. Reduction of Pollution Load at Source Itself

a) Reuse of wet washing water after clarification & treatment which reduced the pollution load in ETP.
b) Adopted new technology in their Bleaching Plant by Oxidative chemical bleaching (Ox) in place of Hydrogen per Oxide (H_2O_2) enriched caustic Extraction (EOP) stage to reduce pollution load in the bleaching effluent.
c) Introduced post bleaching enzymes to reduce bleaching chemicals for the same brightness which helps in reducing pollution load.
d) Introduced four component micro - particle & micro - polymer based chemistry for retention control to achieve 85 % FPR, 65 % FPAR and white water consistency in the range of 0.12 to 0.14 %.
e) Further to recover fiber from excess cloudy water, DAF & Micro filters were installed in Paper Machine section and clear water reused in wire & press section instead of Fresh water.
f) Avoid Paper machine boil out by introducing especially suited biocide program.
g) Installed Heat & Chemical recovery from dissolver vent in Chemical Recovery Boiler.

Reuse of Power Plant RO discharge after treatment.

2.2. Zero/ Minimum Effluent Discharge from Individual Sections of the Mills

I. PULP MILL

(a) Wet Washing Plant

Earlier Back water from Raw material washing plant was being cleaned in a Sand & Pith Filters and conical tanks, thereafter under flow of Conical tank with Sand and Pith used to go to sand riffler which is having compartments where sand and pith is settled. Over flow of Conical tank is taken in a filtrate chest, and is pumped to wet washing system for reuse. Now Under flow of Conical tanks after sand rifler is taken to Clarifier, where remaining TSS settles down and clear filtrate is pumped back to Filtrate chest, Sand and pith Cover shower and Plug screw feeder throat spray instead of Fresh water.

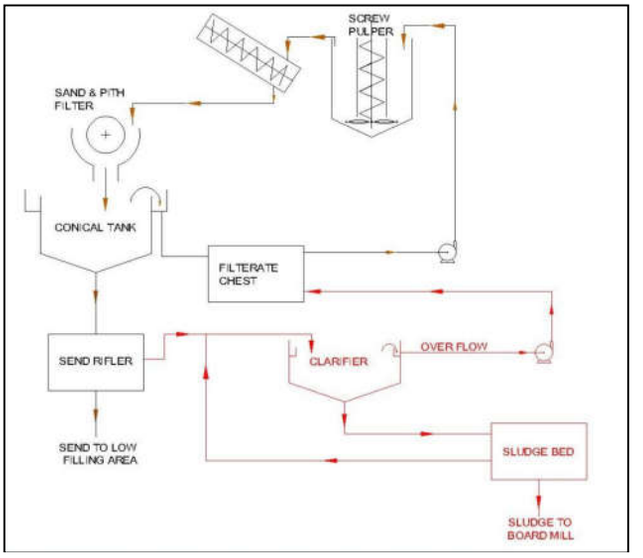

Fig.1. Block diagram for Wet washing Filterate Re-circulation (Pulp Mill)

By increasing black liquor solid, runnability of Recovery Boiler has been increased resulting no furnace oil is being used, except for startup & shut down.

(b) Washing, screening and cleaning.

Raw material after wet washing is sent to Continuous Digester for cooking and then for Pulp Washing, Screening and Cleaning. For Pulp Washing BPML has Four Washers (Three nos. washers before Screening, Cleaning and one no washer after that). Wash water is used on fourth washer. Here foul condensate of Chemical Recovery Plant is used for Washing on Final fourth washer.

c) Bleaching

After Screening Pulp is sent to Bleaching Plant with Bleaching sequence D-O / Ox (Oxidative) / D-1. A new sequence of Ox has been introduced in place of Eop which has reduced pollution load in effluent substantially. BPML is also using Machine white water for Washing Pulp on final D -1 washer.

Filtrate of D-1 stage is used on Ox Washer Mat spray.
Ox Filtrate is used on D-O washer for Mat spray. D-O Filtrate is sent to ETP.

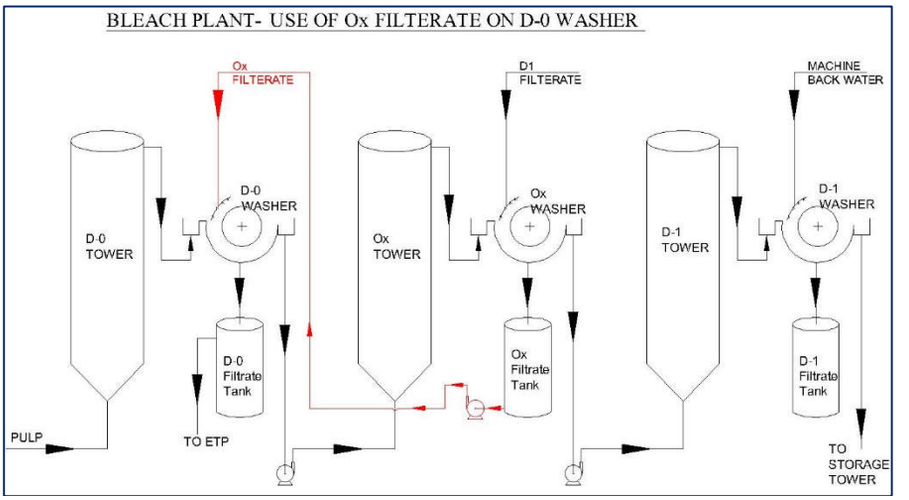

Fig. 2. Block diagram for Re-circulation of Ox Filtrate (Bleaching Plant)

(d) Recycling of Sealing Water for Gland cooling
Pulp Mill was using Fresh water for Pumps glands cooling. BPML has recycled all Sealing water by collecting in a pit & filtering through Vibro-Screen. Hence, Reducing Fresh water consumption for Gland cooling and no water going to drain from Pumps glands.

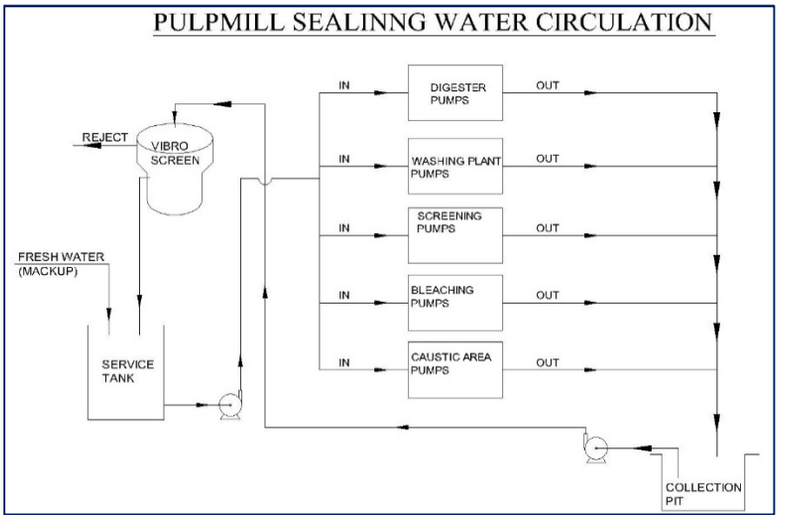

Fig. 3. Block diagram for Re-circulation of Gland cooling water (Pulp Mill)

Summary: Fresh water in Pulp Mill is used only for preparing chemical solutions and water going through glands in pumps. All the above system helped us to save fresh water in Pulp Mill.

Table 1. Reduction in Effluent by Recycling water (Pulp Mill)

Service	Before Recycle	After Recycle	Saving in Fresh Water
	Fresh Water, M3/ Hr.	Fresh Water, M3/ Hr.	M3/ Hr.
Wet washing Water recycling	20	0	20
Ox back water on Do washer mat spray instead of fresh water	93.5	0	93.5
Sealing water of pumps and equipment's recalculated	35	15	20
Chemicals preparation	35	35	0
Air compressor water recycling	2	2	0
Total	185.5	52	133.5

II. Chemical Recovery Plant

Closed loop of water re-circulation in Chemical Recovery Plant
Various schemes are implemented in Chemical Recovery Plant which are mainly as in Fig. 4.
Jobs done for water conservation

•Causticizing plants pumps gland cooling water & Vacuum pump sealing water collected in water pit and pumped to pit in new Evaporator area near Hot water tank.

•Tube cleaning pumps sealing water and pumps pressure control valve discharged water recycled in pit near hot water tank

•In New Evaporator, all pumps sealing water and vacuum pump sealing water collected in pit & pumped to old cooling tower for make-up.

•Recovery boiler pumps sealing water, cascade bearing cooling water taken to water pit near tube cleaning pump & recycled to new cooling tower for make up.

•In old evaporator, all gland cooling water from pumps, vacuum pump sealing water & surface condenser condensate taken to old cooling tower.

•In recovery boiler dissolver vent recovery heat exchanger condensate water taken to dissolver.

•Two collecting pits made to collect all spillage and pumped back to ESP ash dissolving tank for dissolving ash.

•Dregs washer dregs pumped to mud filter & discharged through lime sludge.

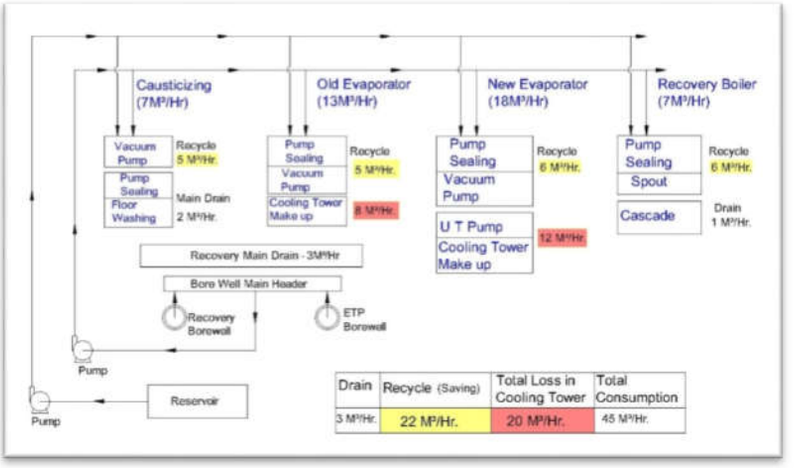

Fig. 4. Recovery Fresh Water Consumption & Distribution

Installed heat & recovery system from Recovery boiler dissolver vapour

Recovery boiler is already equipped with ESP, to further strengthen the air pollution control device, BPML installed a system to increase temp of condensate boiling supplied to Pulp Mill and also recovered chemicals in the form of condensate. The above system works as an Air pollution control device as well as reduced the steam consumption in plant and improved efficiency of Chemical Recovery Plant.

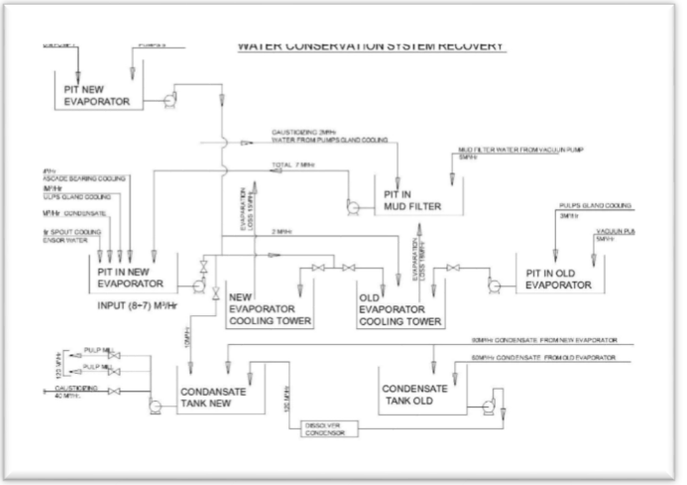

Fig. 5. Water Conservation System Recovery 1

III. Paper Machine

Closed loop of Paper Machine Back water with the implementation of DAF, Micro Filters & Disc Filters.

In Paper Machine, Fresh Water was being used in wire & press part and chemical preparation of stock preparation plant.

BPML has taken major steps to re-circulate Machine white water and water of Centri-cleaners rejects to reduce Fresh water consumption.

For recycling all Machine white water, two nos. specially designed DAF were installed, one for further treatment of excess cloudy water of disc save-all and second DAF for recovery of water coming along with Centri-cleaner's rejects.

Disc Save-all cloudy water is being used in pulp mill bleaching plant for washing of the final pulp at D-1 stage of bleaching and excess Cloudy water is taken into DAF. It's over & under flow is again taken in the system through the broke street and clear water coming out from DAF is further passed through Micro filters to achieve less than 10 ppm clear water.

The Clear water that comes out from DAF and micro filter is reused in Paper Machine at Wire and Press part in place of fresh water.

Water coming out of Centri-cleaner reject pit is collected in underground pit and pumped to the 2nd DAF. Over and under flow again comes in Centri-cleaner reject pit and its clean water is used as a makeup for cooling tower of machine vacuum pump's sealing water.

After installation of 2 nos. of DAF and Micro-filters, the fresh water is being used only in lubrication shower of rolls, high pressure showers of wire & press part, and chemical preparation of stock preparation plant. This equivalent cloudy water is used in pulp mill bleaching section for final washing of pulp.

Thus, the paper machine has become fully closed loop and its drain is almost dried up.

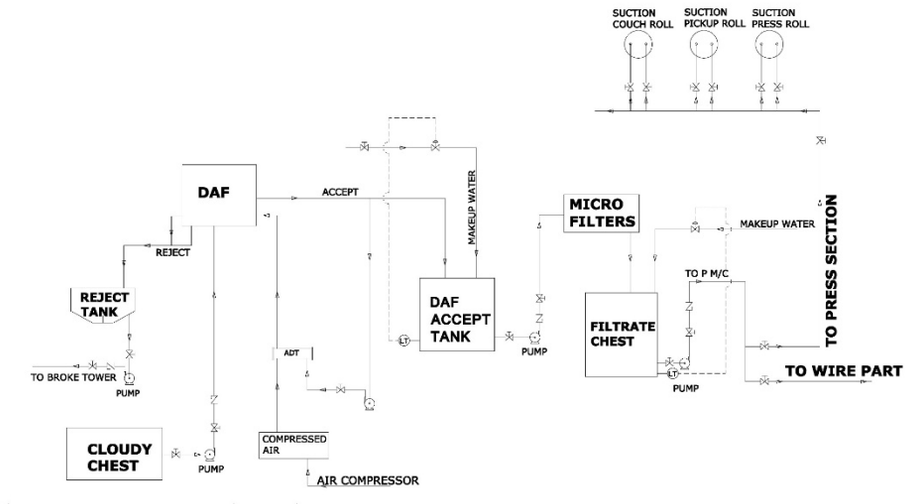

Fig. 6. Paper Machine Close Loop Scheme

Table 2. Details of Fresh Water Consumption before and after installation of DAF and Micro filters in M3/ Hr.

Section	Fresh water consumption before treatment	Replacement with w/w after treatment	Fresh water saving	present fresh water consumption
Chemical Preparation	8	8	0	8
Wire Part				
Wire Rolls	72	72	177.48	86.0
Apron Lip	9.6	9.6		
Trim Knock Off	15.36	15.36		
Ceramic Lube	25.8	25.8		
Window Cleaning	2.52	2.52		
Couch Fog	24	24		
Couch Cleaning	16.2	16.2		
Deckle Board	12	12		
Wire HP	33	0		
Sheet Wetting	32.6	0		
Deckle Lube Top	20.52	0		
`Total	263.6	177.48		
Press Section				

Suction Pick Up Lube	8.4	8.4	93.3	46
Suction Pick Up Flush	40	40		
Suction Press Lube	4.9	4.9		
Suction Press Flush	40	40		
Felt HP	22	0		
Felt Lube	24	0		
TOTAL	139.3	93.3		
COOLING TOWER	26	26	26	0
TOTAL	437	297		140.0

After recycling all white water within paper machine / Stock preparation, the remaining excess water is sent to pulp mill for washing pulp at final Bleach washer (D-1).

Sealing water for vacuum pump
Temperature is the most important factor for vacuum pump seal water. The temperature should be as low as possible for most efficient operation. Fresh water is generally available as much lower temperature than white water. A cooling tower in the water loop helps to keep the water temperature low. Good clarity white water is used as seal water for vacuum pumps and others. Cooling water makeup also from clear white water. Make up water needs because of evaporation.

IV. Power Plant

Closed loop of water re-circulation in Power Plant

Power Plant is having Zero Liquid discharge by recycling the resin, acid and alkali wash in cooling tower by collecting in a tank and neutralizing the pH up to 7.0.
Condensate recovery system is installed and the detailed is as Fig.7 and Fig. 8.

Condensate recovery
(a) Recovery condensate and trap recovery - 95%
(b) Paper Machine - 97%
(c) RO Plant flushing water recycled - 100 M3/day

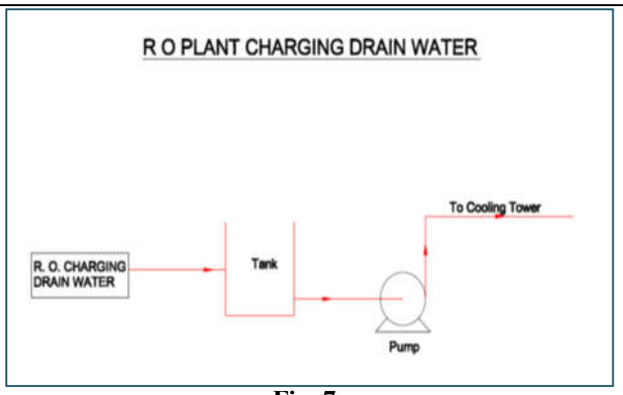

Fig. 7.

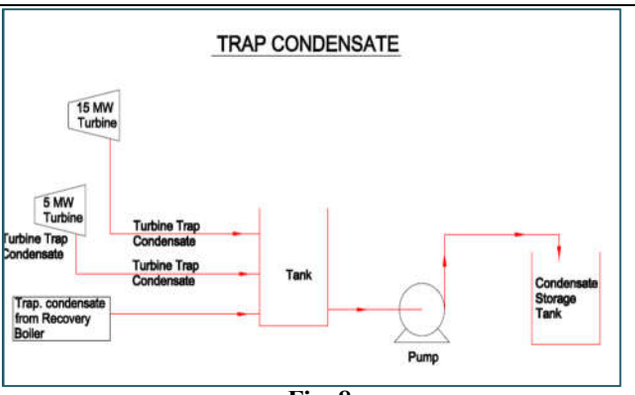

Fig. 8.

Table 3. Summary of Fresh Water consumption

Reduction in Effluent by Recycling water			
Service	**Before recycle**	**After recycle**	**Fresh Water Reduction in %**
	Fresh Water, M^3/ Hr.	**Fresh Water, M^3/ Hr.**	
Pulp Mill	185.5	52	72
Paper Machine	437	140	69
Power House	66.7	62.5	6.3
Others	0.8	0.8	0
Total	690.0 (16,560 m3/Day)	253.3 (6,080 m3/Day)	63.3
Production (TPD)	200	300	
Fresh Water (M3/Ton of Paper)	82.8	20.3	

2.3. Up gradation of ETP Plant

Impact on ETP in terms of effluent Load reduction (After Technological changes in all plants)

By the combined efforts of above schemes the effluent load has reduced drastically which is shown in below table:

Table 4.

	Waste water stream	% Of total ETP load.		Remarks
		Before modification	After modification	Overall app. 60 % of ETP load is reduced after implementation of ZLD schemes in individual plants.
1	Paper Machine, Stock Preparation	App.10 %	Nil	
2	Chemical Recovery Plant	App. 10 %	Nil	
3	Pulp Mill			
	Raw material washing Plant	App.40 %	App.10 %	
	Bleach Plant	App 40 %	App. 30 %	

3. Technological Changes in ETP

As shown in above table that app. 60 % of total Effluent load had been reduced with very small investments as well as with innovative technological changes / process modification, now it was the time to apply same strategy in ETP.
We had bifurcated the ETP influent into two streams which are as below:

(a)Wet Washing Effluent

Wet washing effluent is treated with Hydrated Lime and collected in an equalizing tank where treatment of specialized consortium of anaerobic & Aerobic culture is added to control COD & BOD values. Finally, effluent is settled in clarifier with retention time of 5 to 6 hours.

These cultures are activated in influent & with the help of diffused air. After activation of culture, injected in effluent where they work as a catalyst and degrade the biomass very fast. All this process resulting in very high degree of reduction in terms of COD and BOD values.

After above treatment finally clarified water is again used for Raw material washing.

Fig. 9. Mist Cooling System

Fig. 10. Mist Aeration System

(b) The bleach Plant effluent

The bleach Plant effluent have very low Total Suspended Solids (TSS) i.e. below 200 ppm usually in the range of 80-120 ppm but it has very high temperature i.e. in the range of 55 - 60 ^{0}C and in activated sludge process (ASP) treatment, it is recommended in the range of 30 - 35 ^{0}C. Hence it was required to reduce the temperature.

Technological changes

i. Installation of Mist Cooling system

Normally in the mills it is common practice to install normal "Cooling tower "to reduce the temperature but here in BPML, we adopted the new system i.e. **"Mist cooling system"** which is working on formation of micro particle size (size ≤ 5 micron) which creates mist.

Effluent is collected in an equalization tank and fed through pump to mist cooling system.

In mist cooling system, temperature reduces to the level of 32 to 35 degree Celsius and simultaneously absorbs natural oxygen from atmosphere. The temperature reduction (△t) in the range of 20 - 25 ^{0}C where as in case of normal cooling tower it is 8 ^{0}C. Thus, temperature is maintained in the range of 32-35 ^{0}C.

The bleach plant effluent is fed to aeration tank along with excess clarified wet washing effluent, if any (@ 0 to 15%). The characteristics of combined effluent at inlet of Aeration tank is as below:

Table 5

BOD	750~800 mg/L
COD	2200~2500 mg/L
TSS	100~110 mg/L

Fig. 11. Tertiary treatment Unit

ii. Installation of Mist Aeration System

Mill effluent entering in the Aeration tank, is passing through the Activated Sludge Process treatment (ASP) where we have Surface Aerators for Aeration.

Further, it was strengthened by installing the "Mist Aeration system" in Aeration Tank. Under this system, Bio Mass is exposed to the atmosphere in the form of mist and falls back in Aeration tank after absorbing the natural oxygen from atmosphere.

After strengthening aeration by Mist Aeration System in ASP, a big change in Aeration tank has been observed in the form of "breaking of dead pockets ".

This technology is highly economical and does not require any high capital investment & power as well as well as no extra space requirement.

We have also started usage of special culture in aeration tank to maintain the desired MLSS, after starting this culture, we have stopped adding any nutrients. The reduction of parameters during activated sludge process treatment is as in Table 6.

Table 6

Parameters	Reduction Achieved
BOD	95~97 %
COD	80~85 %

iii. Installation of Tertiary Treatment

Conventional Secondary biological treatment process does not provide the degree of waste water treatment required for most water reuse applications, nor they provide a completely satisfactory method for protecting natural water from pollution by waste discharges.

A process employing Physio-chemical treatment based on solid liquid separation was used and for this especially designed DAF has been installed.

For best results, various lab trials were conducted to achieve optimum results and finally chosen suitable products. The process is consisting of three parts; Coagulation, Flocculation and Separation.

- Coagulation refers to neutralization of negative charges contained in waste water
- Flocculation is based on formation of flocs and bridges which help to separate the solid part from water.
- Separation is the final stage i.e. flocs removal of solids from liquid by air diffusion.

The results were very encouraging as described below:

Table 7

Parameters	Unit	Tertiary treatment inlet	Tertiary treatment outlet	Reduction Achieved
BOD	mg/L	28	8~10	65~75 %
COD	mg/L	400	100~120	65~75 %
TSS	mg/L	50	15~20	60~70 %
Colour	PCU	500	50~60	80~90 %
Turbidity	NTU	50	12~15	70~80 %

Iv. Multi Media Filter

After Physio, Chemical treatment, the effluent is passed through Multi Media filter

VI. Installation of Customized high efficiency R.O Plant

Finally, after all treatments, our management decided to go on R.O Plant and closed the loop by converting the treated effluent in the form of process water and reused in the process along with fresh water.

Table 8

RO Plant Accept Water Quality Parameters				
Parameter	Unit	RO Feed Water	RO Accept water	Mill Ground Water
pH	-	6.5	7.0	7.5
TDS	mg/L	3000	250	280
Total Hardness as CaCO3	mg/L	500	55	225
Chloride as Cl	mg/L	1500	20	10
Total Alkalinity as CaCO3	mg/L	125	25	200
Conductivity	µS	4800	150	175
TSS	mg/L	15	5	4
BOD	mg/L	10	1	1
COD	mg/L	120	12	8
Colour	PCU	60	Colorless	Colorless

(v) Solid waste handling

We have efficient solid waste handling system. We have installed additional Belt Press Filter along with Vacuum Drum filter which are performing very well and achieving dryness of more than 25%.

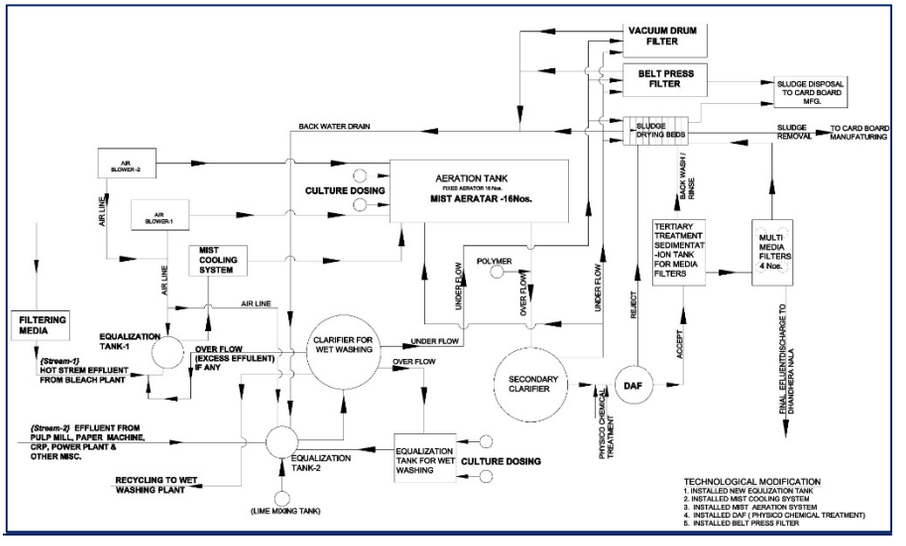

Fig. 12. ETP flow diagram

4. Conclusions

After achieving successful implementation of all technological changes and up gradation. The achievements are as follows: 1. Now, fresh water is being used only for Power Plant, preparation of chemicals and High pressure shower at Paper Machine. 2.Fresh water consumption (without RO Plant) is 20~21 M3/T of Paper and after successful commissioning of RO Plant, it will come down to the level of 6-8 M3/T of Paper. 3.Currently we are meeting all the discharge norms prescribed by Authorities.

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