Reduction of Water Footprint in Agro & RCF Based Pulp And Paper Mills Scope, Possibilities And Available Options

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ABSTRACT

In context , of increasing emphasis on restoring the water quality / health of major rivers / tributaries and very low flows in the rivers during the lean period (most of the year) as well as depleting ground water level , imposition of stringent standards are under consideration by regulatory authorities and are likely to be imposed in coming future. It is to be noted that the existing standards for various pollutional parameters were framed on the assumption that at least 10 times dilution is always available in the river to mitigate the impact of effluent discharge which unfortunately is not the case in reality as in India rainfall is highly uneven and that too takes place mostly for maximum 3 months during monsoon . The situation is going to be tough for pulp & paper industry as it is water intensive and now not only handling of effluent but also disposal of effluent is a major issue before it. The present paper discuss the scope ,possibilities and available options to reduce the water footprint in pulp & paper industry , specially agro & RCF based pulp & paper mills.

Agro & RCF Based Mills A Breif Profile

The agro and RCF based mills in the country produce a variety of unbleached and bleached grade of paper and paper products like writing and printing paper, kraft paper, duplex board and newsprint. The scale of operation varies from 25 to 250 TPD with the use of either single or multiple paper machines. The agro based mills having pulp mill capacity above 100 TPD and producing bleached variety of paper have already installed chemical recovery plant for black liquor management while other mills making unbleached kraft paper from agro residues are operating without chemical recovery plant. All mills generally have effluent treatment facilities comprising primary clarifier, aeration system and secondary clarifier however, the level of performance efficiency varies with below optimum level in most cases resulting in environmental implications . Agro residue based mills (without chemical recovery) in Uttar Pradesh & Uttrakhand have been forced by regulatory authorities to close their chemical pulping facility due to black liquor which is difficult to treat by existing biological treatment process and these mills are either closed or have shifted towards waste paper for time being .

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Assessment of Water Consumption in Agro & RCF Based Mills

Indian paper Industry has been traditionally a highly water intensive industry. Reduction in water consumption became a priority agenda after 2003 when the CREP was introduced which gave a time bound target to reduce the water consumption level to 140 m^3/t paper. It is heartening to note in last 7-8 years the mills have acted proactively and as a result the average water consumption has reduced considerably between 75 -100 m^3/t paper in agro based mills, 35 - 50 m^3/t paper in RCF based mills and some of the mills are operating even at low level of water consumption as indicated in **Table- 1.**

The distribution of fresh water consumption in various operations is depicted as under in Fig.- **1-4 .**

As indicated in Table -1, the figures though encouraging are still not satisfactory as 90 % of the water consumed is discharged by the mills after biological treatment . With issues

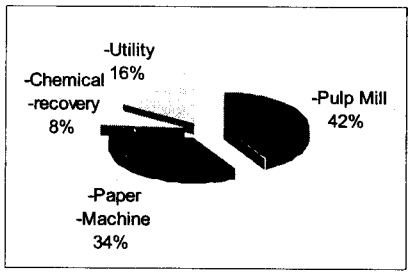

Fig- 1 Process Wise Fresh Water Consumption in Agro Based Writing & Printing Paper Mills

Table- 1
Existing Water Consumption in Agro and RCF based mills

Categories of Mills	Average Water consumption, m^3/t paper
Agro based (writing & printing)	100 (60)
Agro based (Kraft)	75 (54)
RCF based (writing & printing, duplex board and news print)	50 (30)
RCF based (Kraft mill)	35 (10)

Figures in ( ) indicate Best achieved water consumption level in agro and RCF based mills

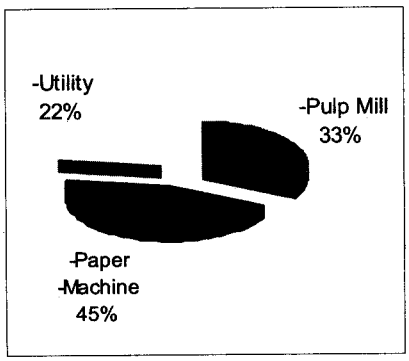

Fig- 2 Process Wise Fresh Water Consumption in Agro Based Kraft Paper Mills

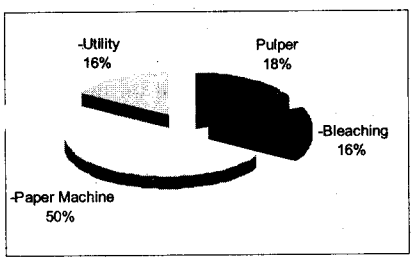

Fig- 3 Process Wise Fresh Water Consumption in RCF Based Writing & Printing paper mills

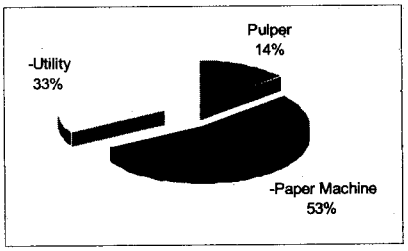

Fig- 4 Process Wise Fresh Water Consumption in RCF Based Kraft paper mills

like water scarcity, impact of treated effluent in receiving streams drawing public and judicial concern , the mills are required to further reduce the fresh water consumption and accordingly minimise the waste water discharge.

Approach For Improved Water Management In Agro & RCF Based Pulp & Paper Mills

The water requirement in pulp & paper mills depends mainly on raw material usage, process & technology employed and the quality of end product. In recent past, considerable efforts have been made by the mills to reduce water consumption , still the level of water consumption in Indian pulp & paper mills is high and varies from mill to mill and even in mills using similar raw materials and producing similar grade of paper. Apart from inadequate control on quantity of water consumed and waste water discharged it has been observed that the adequacy of existing ETP to handle the existing effluent load in most of these mills particularly small mills is generally inadequate and accordingly their performance efficiency is highly variable and is generally unsatisfactory. Essentially fresh water is mainly used in showers on paper machine , for chemical preparation & stock dilution purpose, pulp washing in final bleaching stage , as sealing water in vacuum pumps , for gland cooling of pumps and steam production . On paper machine fresh water is added in the form of showers in the wire section of breast roll, wire return roll, tension roll, guide roll , high pressure cleaning showers , foil and suction box lubricating showers , sheet knock of / sheet cutter showers etc. Water removed from successive stages of dewatering on the wire are collected in wire pit , seal pit , storage tanks or silo .the major portion of water removed from sheet in press section is also collected in a separate tank . Depending on the grades of paper produced , this backwater contains varying proportion of filler , fiber and fines which can be reused as such or after appropriate chemical treatment or clarification or filtration or combination of these . However in small mills it has been observed that many times the fresh water is consumed for purposes which could easily be

Table - 2
Characteristics of Waste Water Generated from Pulp Mill in Agro & RCF based Mills

Parameters	Agro based (W & P)	Agro based (Kraft)	RCF based mill (WP, duplex board & NP)	RCF based (Kraft)
pH	7.5	7.8	6.8	7.2
SS, mg/l	300	275	600	470
TDS, mg/l	1450	1350	1850	1600
COD, mg/l	1400	1150	860	720
BOD, mg/l	750	600	450	410

Remarks:
Since the magnitude of pollution load is high in these streams chemical treatment followed by pressure sand filter / activated carbon filter / micro filter can be used either individually or in combination depending on the requirement / tolerance level of the unit operation where it is desired to be reused.

Table 3
Characteristics of Back Water Generated from Paper Machine in Agro & RCF based Mills

Parameters	Agro based (W & P)	Agro based (Kraft)	RCF based mill (WP, duplex board & NP)	RCF based (Kraft)
pH	6.0	6.2	5.5	5.7
SS, mg/l	460	380	350	550
TDS, mg/l	650	710	950	800
COD, mg/l	610	600	530	430
BOD, mg/l	170	250	160	120

Remarks :
The waste water streams characteristic indicate that after using fiber recovery unit it can be used in pulp mill for stock dilution and consistency regulation and low pressure showers. While after using a combination of clarification / fiber recovery unit and activated carbon and / or pressure sand filter it can be reused in high pressure paper machine showers.

Table - 4
Characteristics of Evaporator Condensate, Vacuum Sealing and Cooling Water in Pulp and Paper Mills

Parameters	Evaporator Condensate (Agro based)	Vacuum sealing	Cooling Water
pH	7.9	8.8	7.3
SS, mg/l	05	10	30
TDS, mg/l	330	430	470
COD, mg/l	1800	20	15

Remarks :
While the evaporator condensate can be reused for pulp washing in BSW and raw material washing , vacuum pump cooling and sealing water can be collected in a sump and reused as process water after clarification / sand filtration and temperature regulation

Processes/ Unit Operations	Required water quality parameters or areas for reuse / recycle of back water & treated effluent
Raw material Preparation (Wet Washing)	Here the major requirement is removal of silica, and other non process elements and so the water quality requirements are comparatively low. So use of fresh water if any should be totally avoided and instead appropriately treated effluent or excess paper machine back water as well as combined condensate of chemical recovery system can also be used in raw material washing .
Pulp Mill : Pulping & Pulp washing Bleaching	In pulp mill the major areas for reuse / recycle of back water / are digester makeup , pulp washing (BSW & Decker Washer) etc Similarly foul condensate can be reused on BSW A part of black Liquor (in case of agro kraft mills) can be reused for digester makeup For bleaching showers back water to be recycled should meet a quality level : pH ~ 7 , TSS - < 100 ppm, Hardness <250ppm Colour – colourless
Paper Machine	On paper machine fresh water is added in the form of showers in the wire section of breast roll, wire return roll, tension roll, guide roll , high pressure cleaning showers , foil and suction box lubricating showers , sheet knock of / sheet cutter showers etc. Water removed from successive stages of dewatering on the wire are collected in wire pit , seal pit , storage tanks or silo .The major portion of water removed from sheet in press section is also collected in a separate tank . Depending on the grades of paper produced , this backwater contains varying proportion of filler , fiber and fines which can be reused as such or after appropriate treatment or clarification or filtration . The characteristics of recycled water for being suitable for reuse / recycle in different showers of paper machine are given as under : Suspended Solids content (mg/l) – Recommended use 0-50 – Equivalent to filtered fresh water and can be used anywhere 50-75 – Can be used in fixed orifice nozzles of 1 mm diameter and larger 75-100 – Can be used in fixed orifice nozzles of 1.5 mm diameter and larger 100-200 – Can be used in fixed orifice nozzles of 3 mm diameter and larger The other parameters include : pH ~ 7 , Hardness <250ppm , Colour – colourless Other than paper machine the other areas where clarified back water can be reused are Decker thickner showers, Vacuum Washers, Centricleaner rejects dilution , pulp dilution , broke slushing , consistency control, Johnson screen showers etc
Utilities	The major bottleneck in the reuse of back water in these areas is build up of scales due to accumulation of TDS. As such the water quality requirement in these areas is pH ~7, Silica -0.02 ppm Total Hardness -< 250ppm
Cooling water	Major water quality requirement - Temperature < 20-30 °C, pH ~ 7.0 , Conductivity < 2000 us/cm, Chloride < 200ppm
Sealing Water	Major water quality requirement for water ring vacuum pumps is TSS < 50 mg/l , pH, > 5.5 , TDS <500 mg/l , Hardness <200mg/l , Chlorides < 100 mg/l , Sulphates < 100 mg/l
Chemical Preparation (dilution of Retention Aid, flocculant agents , starch cooking etc)	Major water quality requirement in these areas is pH ~6-8 , Total Solids <500 ppm ,TSS < 120 ppm , Total Hardness -< 250ppm, Fungi/ Algae < 2UFC /ml Cationic Demand < 350 ueq/l
Others	DM plant regeneration and sand filter backwash can be used in areas for ash quenching Treated effluent can be used as fire hydrant and for ash quenching

carried out with back water / treated effluent with or without treatment. As such for efficient water management in the small pulp and paper mills an awareness about the strategies or available options as well as successful case studies are needed in order to tap the loop holes which are a cause for excess water consumption as well as replicate the water conservation programmes successfully adopted by other mills. These include:

(a) Efficient Use of Water in the Process

One of the major reasons for high consumption of fresh water in small mills is lack of process optimisation and obsolete technologies as well as awareness about actual water consumption / discharge due to lack of flow meters . The first step towards reducing the water consumption should be installation of calibrated flow meters at fresh water intake (bore well) as well as at various process units . Once these are in place, the mill may estimate the water balance as well as individual process units water requirement in terms of tolerance level as well as actual quantity required . This should be followed by development of strategies / identification of back water / waste water streams which could be recirculated / reused back into the process without or after appropriate treatment.

(b) Identification of areas of Reuse / Recycle of Waste water / Back Water Streams & Water Quality Requirement for Different Process Operations

For each unit operation involved in paper making i.e. from raw material preparation to finished product , the quality of water required varies. As such reuse / recycle of back water / treated effluent without or with treatment depends on case to case basis. A few required water quality parameters as well as suggested areas for reuse / recycle of back water based on various reported case studies are indicated on left side.

(c) Reuse / Recycle of Waste water / Back Water

Characterisation & quantification of the back water / waste water streams generated from various process operations is the first step to evaluate the possibility of their reuse / recycle back into the process as well as extent of treatment required to meet the

Low Polluted	Gland cooling , Sealing Water , Cooling Water, DM water
Moderately Polluted	Vibratory screen, centricleaners , decker thickner , Paper Machine Back water
Highly polluted	Raw material washings , bleach plant effluents and black liquor spillages

Table - 5
Treatment of Pulp Mill Effluent Using Combination of Chemical Treatment & Pressure Sand Filter

Parameters	Pulp Mill Effluent		Recycle / reuse options
	Before treatment	After treatment	
pH	6.5-8.0	6.5-7.5	- Can be used for Raw material washing - Can be used as Digester make up water - Can be used at Hydrapulper - Can be used for pulp dilution at Decker, Centricleaners, etc.
SS, mg/l	300-600	10-20	
TDS, mg/l	1350-1600	1000-1200	
COD, mg/l	700-1400	400-800	

Table - 6
Treatment of Paper Machine Back Water Using Combination of Save all & Micro Filtration

Parameters	Paper Machine Back Water		Recycle / reuse options
	Before treatment	After treatment	
pH	5.5-6.5	5.5-6.5	- Showers at Johnson screen - Showers at unbleached and bleached Decker at agro & RCF based paper mills - Pulp dilution before bleaching stage in agro & RCF based paper mills - Showers of multi stage bleaching plant in agro based mills making W & P paper - Can be used at low and high pressure showers at paper machine - Vacuum sealing and Gland cooling water etc.
SS, mg/l	350-550	10.0-15.0	
TDS, mg/l	650-950	550-850	
COD, mg/l	430-610	100-150	

Table -7
Treatment of Final Discharge of an Agro based Mill with Activated Carbon

Parameters	Wt of Activated Carbon used / Liter effluent , gm			
	2.0	2.0 + Polymer	5.0	5.0 + Polymer
Initial COD, mg/l	356	356	356	356
Final COD, mg/l	190	148	170	140
% COD Reduction	**47**	**58**	**52**	**61**
Initial Colour PCU	1500	1500	1500	1500
Final Colour PCU	361	425	89	30
% Colour reduction	**76**	**72**	**94**	**98**
Initial Lignin , mgl	157	157	157	157
Final Lignin , mg/l	47	55	17	10
% Lignin reduction	**70**	**64**	**89**	**94**

tolerance level of individual unit operations. The characteristics of pulp mill waste water , paper machine back water, evaporator condensate, vacuum sealing water & cooling water are indicated in **Table 2 , 3 & 4.** on page no. 130

(d) Segregation of Waste Water / Back Water Streams

A prior requisite for successful water management is segregation of back water and other waste water streams according to the pollution load and accordingly using them with or without treatment . The quality of waste water streams / back water streams can be categorized as shown in the left side.

(e) Application of Tertiary Treatment to Minimise Water Consumption

In order to maximise the recycling of waste water or back water into the system the tertiary treatment of biologically treated effluent is the final option. This may include application of chemical treatment or pressurised sand filter / micro filter / activated carbon filter / membrane filtration etc of removal of colour , suspended and dissolved impurities. Application of these technologies either individual or in combination will depend on case to case basis. The quality of the pulp mill effluent & paper machine back water which could be achieved after using combination of tertiary treatment options is indicated in **Table 5 & 6**

TREATMENT OF BIOLOGICALLY TREATED EFFLUENT

(A) With Activated Carbon

Further as per the laboratory studies carried out by CPPRI on impact of activated carbon filter on final discharge characteristics of an agro based pulp and paper mill producing writing and printing grade of paper , 75 95 % reduction can be achieved using activated carbon between 2 gm 5 gm /Litre **(Table - 7)** . Addition of polymer further improves the reduction rate marginally .

(B) With Combination of Coagulant & Flocculant

Similarly chemical treatment trails with same mill effluent using a combination of polymer and Ferrous sulphate & Titanium Oxide (a low cost chemical) resulted in reduction of colour from 1500 to below 200 PCU (more than 85 % reduction) **(Table -8)**

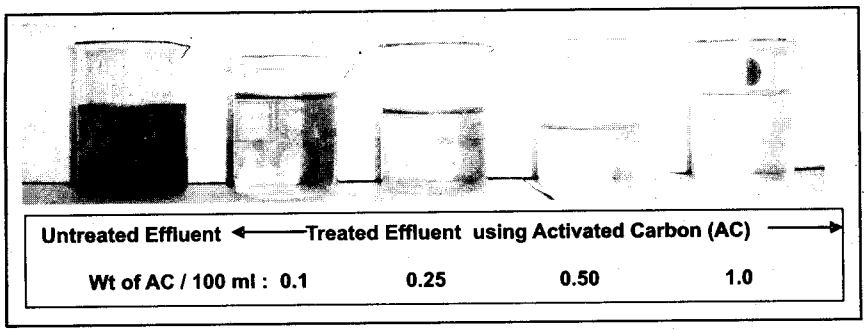

Fig 5 Treatment of Final Discharge of an Agro Based Mill with Activated Carbon

Table -8
Chemical Treatment of Final Discharge of Agro based Pulp & Paper Mill

Parameters	Ferrous Sulphate & Titanium Oxide +Polymer 0.2%	Ferrous Sulphate & Titanium Oxide + Lime + Polymer 0.2%	Ferrous Sulphate & Titanium Oxide + Lime + Polymer 0.2%
Initial COD, mg/l	356	356	356
Final COD, mg/l	171	198	177
% COD Reduction	**52**	**44**	**50**
Initial Colour PCU	1500	1500	1500
Final Colour PCU	**141**	**190**	**184**
% Colour Reduction	**91**	**87**	**88**

MAJOR BOTTLENECKS OR LIMITATIONS IN ADOPTION OF PHYSICO- CHEMICAL TREATMENT

Inspite of the strategies / technologies being available to implement water conservation programmes, their success rate specially in agro based mills is limited as well as variable due to :

- Use of mixed raw materials depending upon seasonal availability
- High silica content in raw material and presence of non process elements leading to their build up in the process and eventually affecting product quality
- Production of multiple grades of paper on the same machine as per market requirement
- Over loading of existing fiber recovery units / save all resulting in low level of performance efficiency (SS removal) thus restricting the reuse / recycle potential.
- The conventional ETP is not sufficient in itself to treat the effluent to make it suitable for reuse into the process.
- Use of ultra/ nano filtration , reverse osmosis has still not been commercialised due to high investment , operational and maintenance cost.

CONCLUSIONS

Efforts either voluntary or enforced will have to be taken to reduce the water footprint of Indian pulp & paper industry. Optimisation of process operations for efficient use of fresh water as well as segregation and collection of different backwater and waste water streams in accordance to magnitude of pollution load , adoption of appropriate white water clarification units , installation of back water collection tanks of adequate capacity are the key steps to be adopted for reducing the water consumption or discharge . The increased reuse & recycle of back water and treated mill effluent can be achieved through tertiary treatment involving combination of chemical treatment and filtration technologies like micro filter , activated carbon filter , pressurised sand filter etc . The best closed systems are reported to use fresh water only in critical areas and segregation of waste water streams or back water of different quality and reusing it as per process requirements. Reuse of backwater in addition to conserving fibers , fines , fillers help in significant reduction of waste water discharge. There is a need to develop indigenous capability as well as to improve the confidence of the industry for use of tertiary treatment technologies for treatment of back water / waste water for its increased reuse back into the process .

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