

Validation of Feasibility of Zero Liquid Discharge in a RCF based Kraft Paper Mill – A Case Study

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Background

- ❑ Charter for Water Recycling & Pollution Prevention in Pulp and Paper Industries in Ganga River Basin



- ❑ Reduction in fresh water consumption through process optimization, increased reuse and recycling of treated effluent / back water and ETP upgradation.

- ❑ The reduction in fresh water consumption through reuse / recycle of back water / treated effluent



- ❑ Significant increase in pollution load thus requiring exhaustive treatment facility up to tertiary treatment level to treat the effluent.



- ❑ Some RCF based kraft paper mills instead of opting for ETP upgradation, have opted to go for Zero Liquid Discharge (ZLD) without any major technological intervention and have discontinued their ETP operation.



Driving Forces

- ❑ To save O & M costs involved in ETP operation
- ❑ Avoid non compliance issues.

Issues

- ❑ Difficult for the mills to prove their ZLD status
- ❑ Difficult for the regulatory authorities to validate the ZLD status without any technical background.
- ❑ Need for a methodology to validate ZLD status

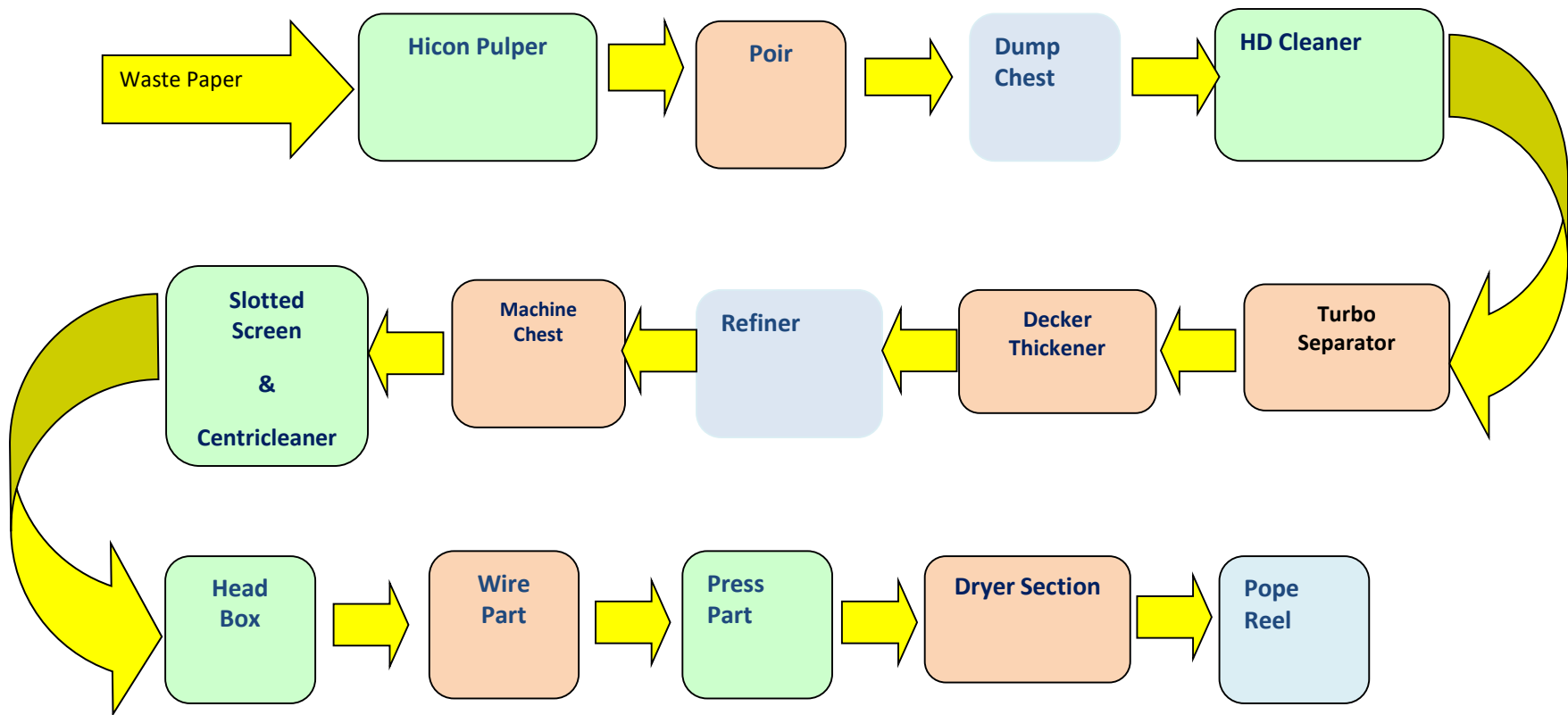
In this context , CPPRI took up the initiative to carry out indepth studies for evaluating technical feasibility of ZLD status as claimed by the RCF based pulp and paper mills in a systematic and methodical manner.



Mill Profile

| | |
|--------------------------------|---|
| Category | RCF based |
| Raw Material | Indigenous Mixed Waste Paper |
| End Product | Kraft Paper |
| Production capacity | 90 tpd |
| Fresh water Consumption | 140 m³ / day = 1.56 m³ / t paper |

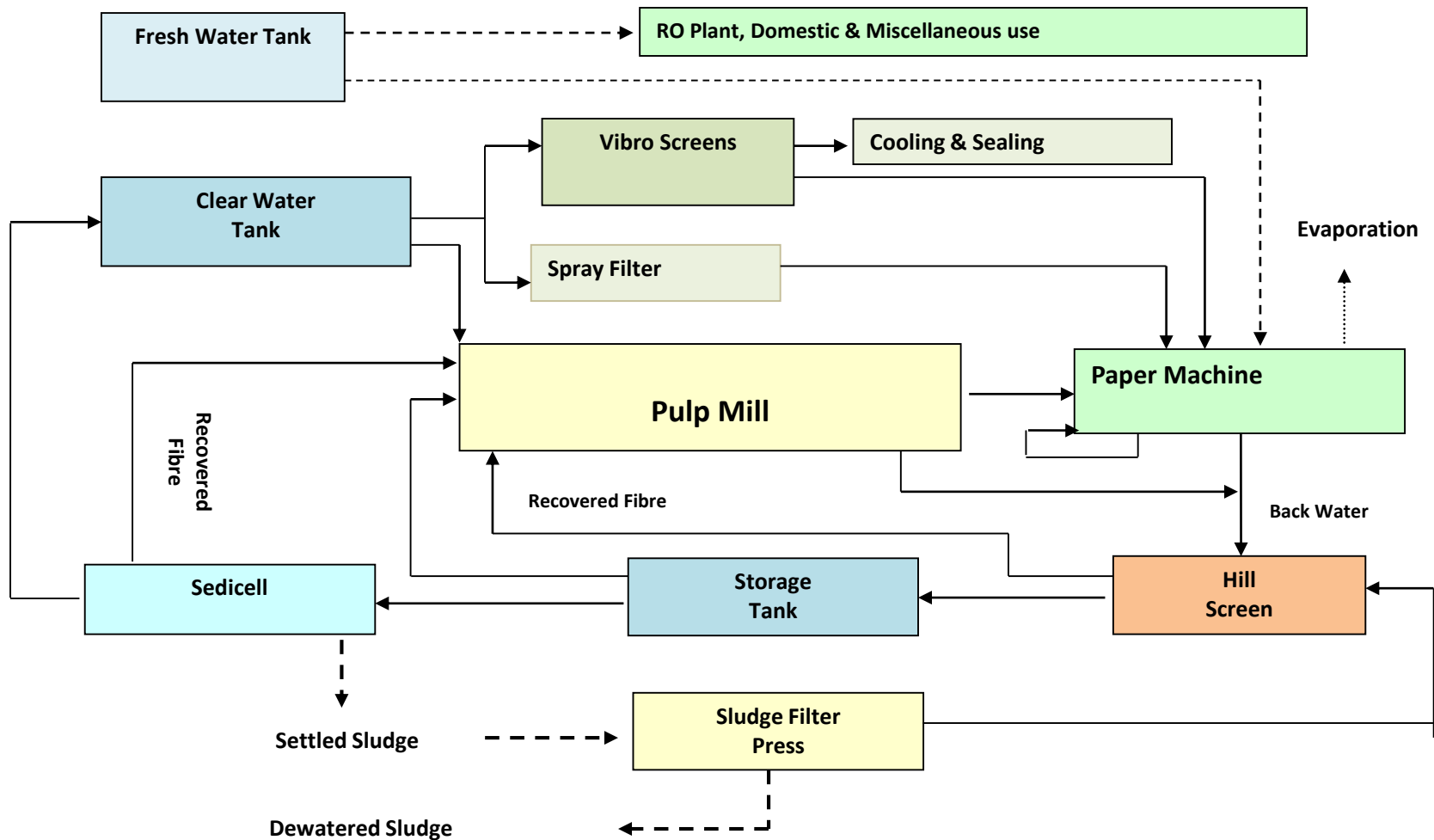




Fresh Water Consumption by the Selected RCF based Kraft Paper Mill

| Unit | Fresh Water Consumption, m ³ /day |
|------------------------------|--|
| Pulp Mill | Nil |
| Paper Machine | 90 |
| Cooling & Sealing | Nil |
| RO Plant | 35 |
| Spray Filter (For Back Wash) | 5 |
| Domestic & Miscellaneous | 10 |
| Total | 140 |





- *An electromagnetic flow meter has already been installed to monitor the volume of back water reused /recycled into the process*
- *Further an on- line camera facing back water treatment system and back water reuse line is already installed which is linked to CPCB server.*

| Units | Specification/Status | Remarks |
|--|---------------------------------|--|
| Hill Screen | 3.5 m x 4.0 m x 4.0 m | Fiber Recovery & Filtration |
| Storage Tank | Capacity: 500 m ³ | Uniform feeding to Sedicell & Pulp Mill |
| Sedicell | Capacity: 250 m ³ | Fiber Recovery & removal of settleable solids |
| Clear Water Tank | Capacity: 400 m ³ | Uniform feeding to spray filter , vibro screen and pulp mill |
| Vibro Screens (3 Nos.) | Capacity: 75 m ³ /hr | Removal of Suspended impurities |
| Spray Filter | Capacity: 50 m ³ /hr | Removal of fines and colloidal particles |
| Filter Press (Plate & Frame Type) | 52 plates | Dewatering of sedicell settled sludge |

Validation of Zero Liquid Discharge (ZLD) Status – Methodology Adopted



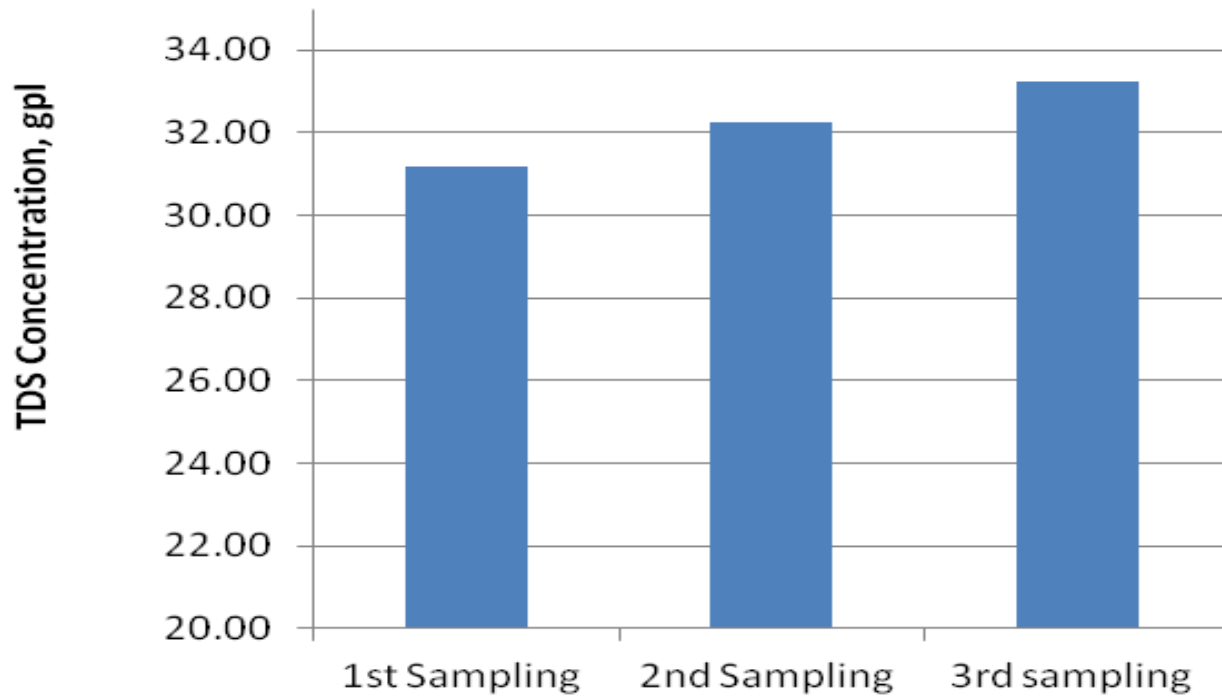
- ❑ Monitoring of TDS, COD & BOD level in back water samples collected at different time intervals from various sources of the mill
- ❑ Water Balance w.r.t. Water Intake v/s Water Loss
- ❑ Material balance w.r.t. inputs & outputs

- ❑ Estimation of the generation of TDS, COD & BOD per day in back water due to waste paper & chemicals/additives used by the mill
- ❑ Estimation of the TDS, COD & BOD concentration in back water at which their generation equals to their loss
- ❑ Evaluation of TDS, COD and BOD loss due to carryover with finished paper & solid rejects w.r.t. their generation due to waste paper & chemicals used by the mill

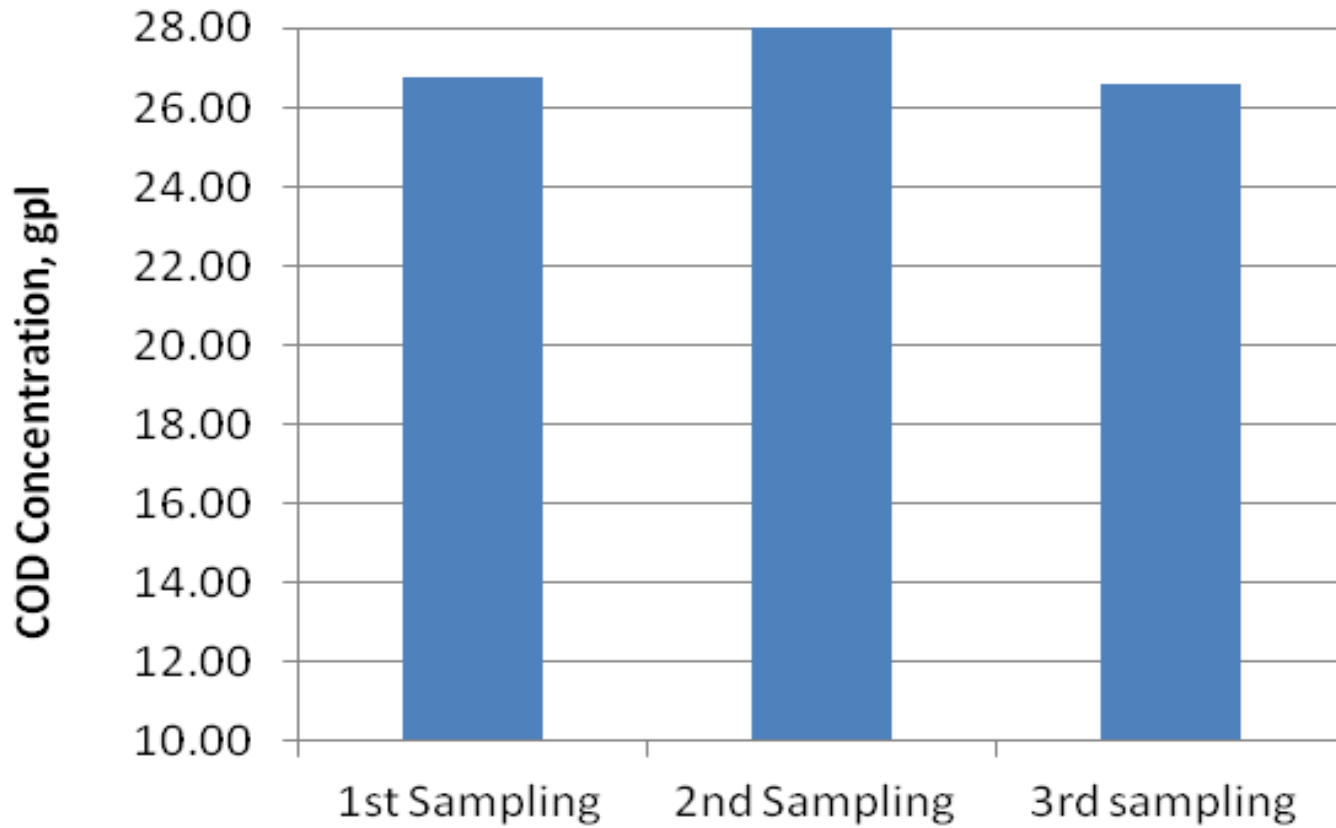
Periodical Monitoring of Pollution Load in Back Water

| S. No. | Period | Sources | TDS, mg/l | COD, mg/l | BOD, mg/l |
|--------|--|--|--------------|--------------|--------------|
| 1. | 1 st sampling | Paper Machine Back Water (Supernatant) | 29778 | 26285 | 17905 |
| | | Clear Back Water | 31183 | 26780 | 18477 |
| 2. | 2 nd sampling | Paper Machine Back Water (Supernatant) | 31766 | 26851 | 19035 |
| | | Clear Back Water | 32246 | 28006 | 20062 |
| 3. | 3 rd sampling | Paper Machine Back Water (Supernatant) | 33824 | 24432 | 18626 |
| | | Clear Back Water | 33242 | 24613 | 18498 |
| 4. | Average characteristics of Paper Machine Back Water (Supernatant) | | 31789 | 25856 | 18522 |
| 5. | Average characteristics of Clear Back Water (After Sedicell) | | 32224 | 26466 | 19012 |

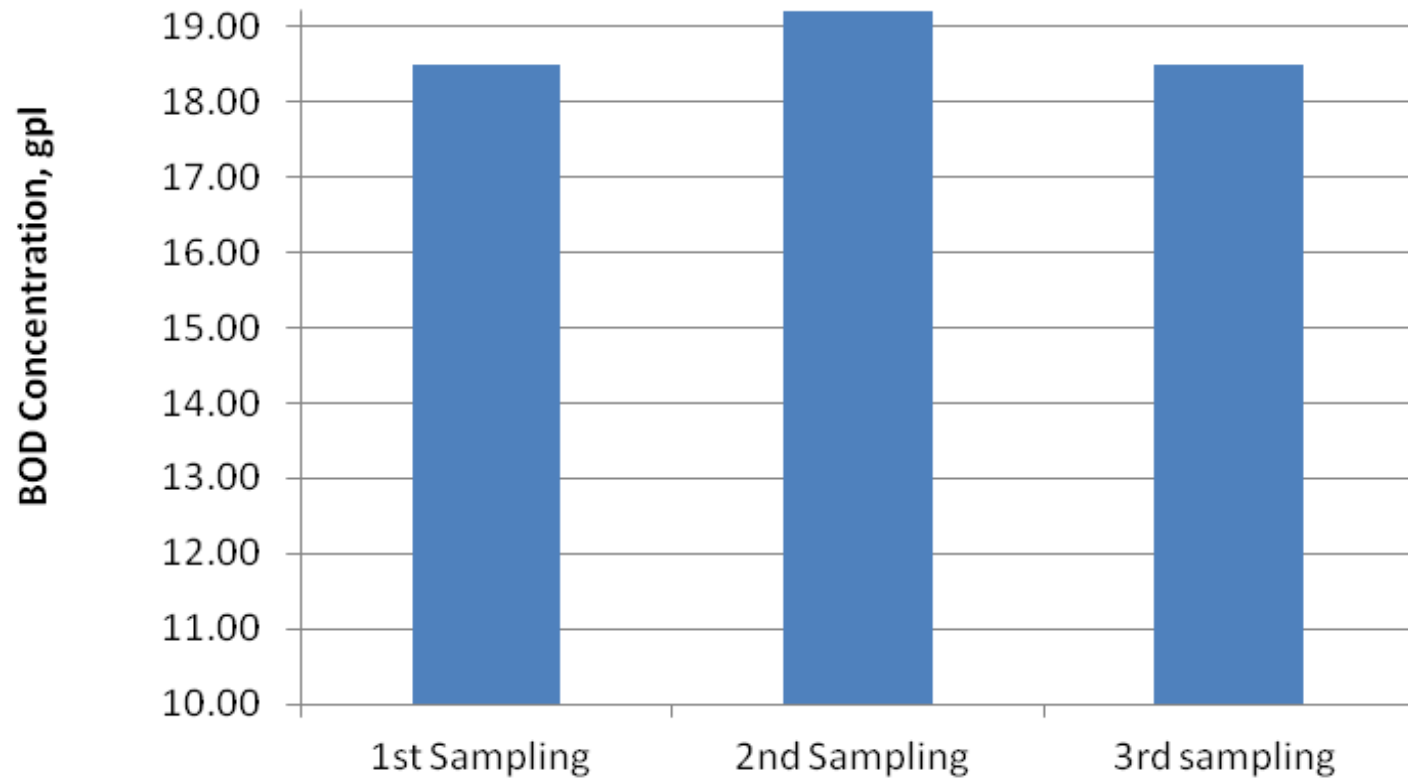
TDS level at different time intervals



COD Level at different time intervals



BOD Level at different time intervals



Estimation of Water Intake v/s Water Loss

*

| Water Intake, m ³ /day | | Water Loss, m ³ /day | |
|--|-----------|---|----|
| Paper machine | 90 | Evaporation from dryer section \Inlet dryness: 45 % (w/w) \Outlet dryness: 94.5 % (w/w) | 99 |
| RO plant* | 35 | Steam Loss (Condensate recovery = 85 %) | 20 |
| Moisture with waste paper** | 7 | Carry over with solid rejects | 5 |
| Spray filter (for back wash) | 5 | Moisture in finished paper ## | 5 |
| Miscellaneous uses | 10 | Miscellaneous loss/Open evaporation | 18 |
| Total water intake, m³/day=147 | | Total water loss, m³/day = 147 | |

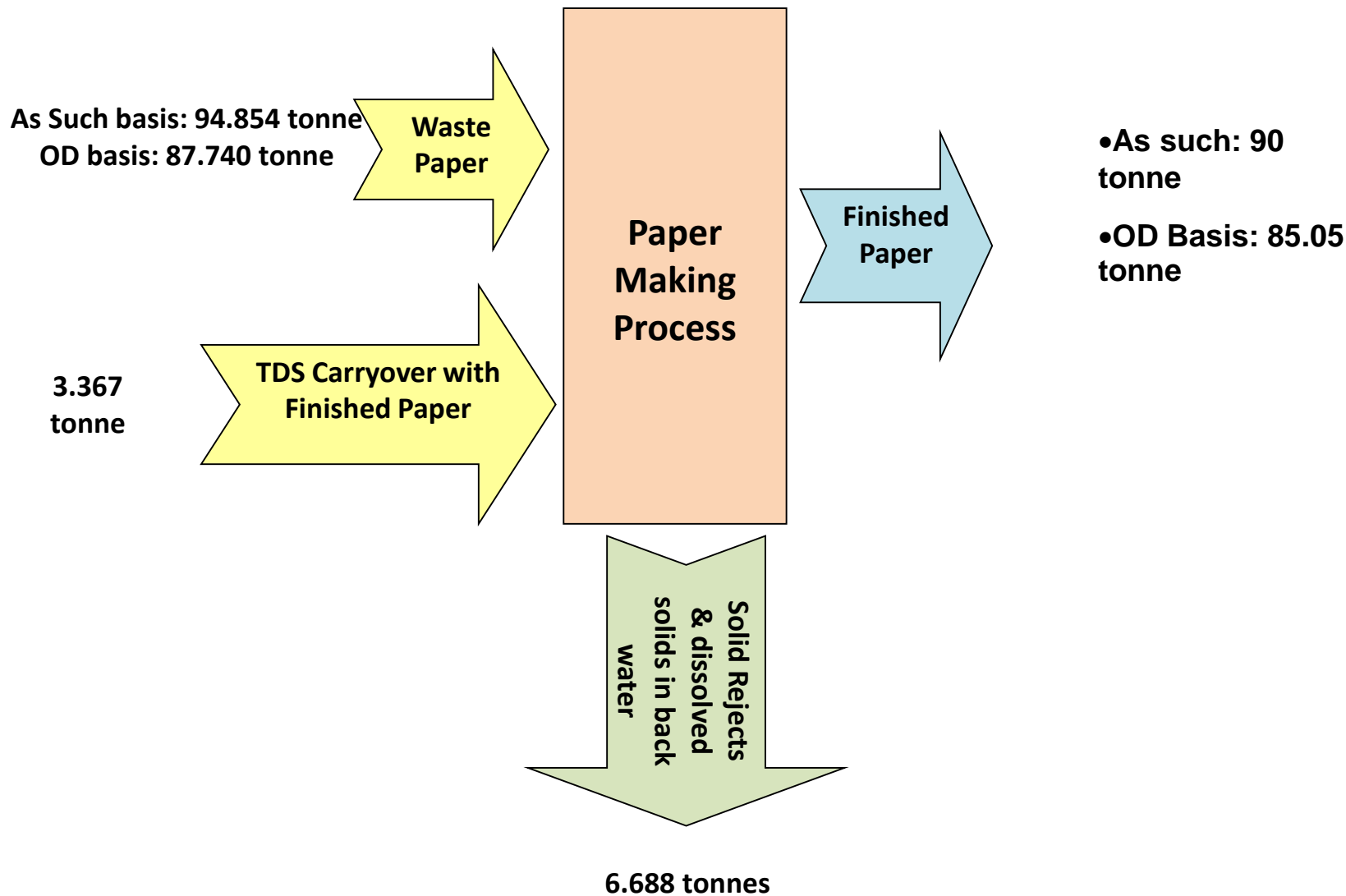
RO rejects are mixed in fresh water tank ** Average moisture: 7.5 % ## 5.5%

Material Balance

| Inputs, tonnes/day | | Outputs, tonnes/day | |
|--|--------------------------------------|--|--------------------------------------|
| Waste Paper# <ul style="list-style-type: none">• As such basis• OD Basis | 94.854 87.740 | Finished Paper## <ul style="list-style-type: none">• As such basis• OD Basis | 90 85.05 |
| Additives/chemicals | 0.810 | Solid Rejects (Sand, sludge, plastic, pins etc.) | 3.000 |
| TDS carryover with paper sheet going to dryer section @ 45 % dryness | 3.306 | Solids dissolved in back water | 3.688 |
| Total | 91.856 92 (approx) | Total | 91.738 92 (approx) |

#Average moisture: 7.5 % ## 5.5%





Material Balance in Paper Making

Lab Studies on Estimation of TDS, COD and BOD Generation in back water from Waste Paper

- ❑ Waste paper collected from selected paper mill was processed on lab scale using hicon pulper following mill pulping variables
- ❑ Multiple hand sheets were formed using British sheet former as per TAPPI standard
- ❑ The back water drained out from sheet former was characterized for TDS , COD & BOD

Estimated Generation of TDS, COD and BOD in back water from Waste Paper

| Particulars | kg/tonne waste paper | kg/day (at Mill Scale) |
|----------------|----------------------|----------------------------|
| TDS generation | 42.02 | 3688 |
| COD generation | 34.59 | 3056 |
| BOD generation | 24.45 | 2160 |



Estimation of TDS Concentration of back water at which its generation equals to its loss

| Particulars | Day | | | | | |
|--|-----------------|------------------|------------------|------------------|------------------|-------------------|
| | 1 st | 15 th | 30 th | 60 th | 90 th | 120 th |
| TDS generation, kg/day (Constant) | 3688 | 3688 | 3688 | 3688 | 3688 | 3688 |
| Back water in closed loop, m ³ /day (Constant) | 2500 | 2500 | 2500 | 2500 | 2500 | 2500 |
| TDS concentration in back water, gm/l | 1.47 | 16.5 | 24.95 | 31.5 | 33.2 | <u>33.7</u> |
| TDS loss, kg/day (Carryover with Finished Paper and solid rejects) | 160.8 | 1798.3 | 3433.8 | 3621.3 | 3648.1 | 3670.5 |

Estimation of COD Concentration of back water at which its generation equals to its loss

| Particulars | Day | | | | | |
|--|-------|--------|--------|--------|--------|--------|
| | 1st | 15th | 30th | 60th | 90th | 120th |
| COD generation, kg/day (Constant) | 3056 | 3056 | 3056 | 3056 | 3056 | 3056 |
| Back water volume in closed loop, m ³ /day (Constant) | 2500 | 2500 | 2500 | 2500 | 2500 | 2500 |
| COD concentration in back water, gm /l | 1.22 | 13.67 | 20.7 | 26.1 | 27.5 | 27.9 |
| COD Loss, kg/day (Carryover with finished paper and solid rejects) | 133.2 | 4090.2 | 2253.7 | 2845.4 | 3000.7 | 3041.5 |

Estimation of BOD concentration of back water at which its generation equals to its loss

| Particulars | Day | | | | | |
|--|------|--------|--------|--------|--------|--------|
| | 1st | 15th | 30th | 60th | 90th | 120th |
| BOD generation, kg/day (Constant) | 2160 | 2160 | 2160 | 2160 | 2160 | 2160 |
| Back water volume in closed loop, m ³ /day (Constant) | 2500 | 2500 | 2500 | 2500 | 2500 | 2500 |
| BOD concentration in back water, gm/l | 0.86 | 9.7 | 14.6 | 18.4 | 19.5 | 19.7 |
| BOD Loss, kg/day (Carryover with finished paper and solid rejects) | 94.2 | 1053.2 | 1592.9 | 2011.1 | 2120.9 | 2149.7 |

TDS, COD and BOD in back water at ZLD

| Parameters | Concentration in Back water , gpl | |
|------------|-----------------------------------|-----------|
| | Actual | Estimated |
| TDS | 32.22 | 33.7 |
| COD | 26.46 | 27.9 |
| BOD | 19.02 | 19.7 |

Evaluation of TDS, COD and BOD Loss Due to Carryover with Finished Paper & Solid Rejects w.r.t. Their Estimated Generation Due to Waste Paper & Chemicals Used



Evaluation of TDS generation and its Loss

| Particulars | Values |
|--|-------------------------------------|
| Back water carryover with wet paper sheet at dryer inlet | 104 m ³ @ 31789 mg/l TDS |
| Back water carryover with solid rejects | 5 m ³ @ 32224 mg/l TDS |
| TDS carryover with finished paper, kg/day | 3306 |
| TDS carryover with solid rejects, kg/day | 161 |
| Total TDS loss, kg/day | <u>3467</u> |
| Estimated TDS generation, kg/day | <u>3688</u> |



Evaluation of COD generation and its Loss

| Particulars | Values |
|--|-------------------------------------|
| Back water carryover with wet paper sheet at dryer inlet | 104 m ³ @ 25856 mg/l COD |
| Back water carryover with solid rejects | 5 m ³ @ 26466 mg/l COD |
| COD carryover with finished paper, kg/day | 2689 |
| COD carryover with solid rejects, kg/day | 132 |
| Total COD loss, kg/day | <u>2821</u> |
| Estimated COD generation, kg/day | <u>3056</u> |

Evaluation of BOD Generation and its Loss

| Particulars | Values |
|--|--|
| Back water carryover with wet paper sheet at dryer inlet | 104 m ³ @ 18522 mg/l BOD |
| Back water carryover with solid rejects | 5 m ³ @ 19012 mg/l BOD |
| BOD carryover with finished paper, kg/day | 1926 |
| BOD carryover with solid rejects, kg/day | 95 |
| Total BOD loss, kg/day | <u>2021</u> |
| Estimated BOD generation, kg/day | <u>2160</u> |

MAJOR BOTTLENECKS / LIMITATION :

- Compromise with the product quality (reduction in BF by 15-20%)**
- Reduction in wire & felt life by 20- 40 %.**
- Increased corrosion and plugging of the equipments / pipe lines**

- Need to optimize the impact of TDS, COD & BOD on process operation and paper quality**
- Need to evaluate incorporation of effluent treatment system in the loop**
- Need to control slime by using slimicides / biocides**



MAJOR BOTTLENECKS :

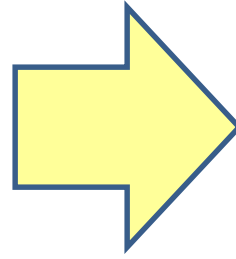
❑ Problem of odor in mills' atmosphere and product

- Increase in build up organic compound in back water
- Organic compounds are converted into organic acid or volatile fatty acids by acidifying bacteria under anaerobic conditions. These VFA are main sources of odor
- Sulphate reducing bacteria also convert VFA into Hydrogen sulphide which has smell of rotten eggs
- Incorporating anaerobic treatment / aerobic treatment in the loop can help in reducing the odor
- Avoiding excess storage time in back water holding tanks
- Establishing short water circuit instead of long circuit.
- Provision of air in the back water recycling tank may also help in reducing the odor to a certain extent.

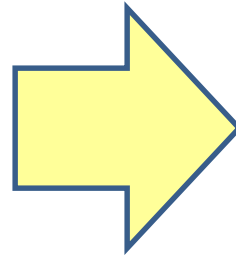


Summary

ZLD Validation

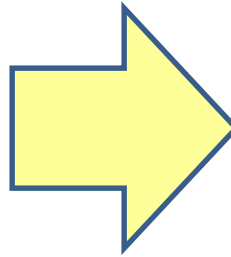


The fresh water consumption
140 m³/day (1.56 m³/
tonne_{paper})

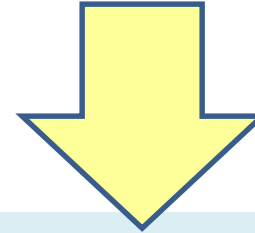


High level of **TDS (32224 mg/l)**, **COD (26466 mg/l)** and **BOD (19012 mg/l)** in back water at different time intervals

ZLD Validation

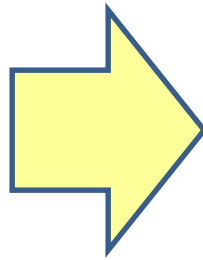


The lab scale studies on estimation of pollution load generation from raw material and subsequent theoretical estimation of buildup of pollution load



- ❑ The concentration at which level of TDS, COD and BOD in back water equals to their losses as carryover with finished paper & solid rejects is about **33.7 gpl , 27.8 gpl & 19.7 gpl** respectively
- ❑ This is in close proximity to the existing level of TDS , COD and BOD analyzed in the clear back water collected i.e. **32.22 gpl, 26.47 gpl and 19.01 gpl** respectively.

ZLD Validation



In lab studies conducted, the generation of TDS, COD & BOD was found around **3688, 3025 and 2160 kg/day due to waste paper** (100 % indigenous) & chemicals used

This is almost equivalent to the values of TDS, COD and BOD lost during paper making process.

Finally

- ❑ CPPRI is working on developing a protocol to evaluate to feasibility of zero liquid discharge in RCF based pulp and paper mills producing different grades of paper
- ❑ Mills reported to be on ZLD are requested to share with CPPRI their valuable inputs, suggestions , experience, success / problems etc which could be helpful in framing the protocol.
- ❑ CPPRI also solicit cooperation from ZLD mills in facilitating detailed mill studies





Thanks

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