TECHNICAL FEASIBILITY OF COMPLETE RECYCLING OF TREATED TRADE EFFLUENT BY THE UNITS MANUFACTURING WRITING AND PRINTING PAPER FROM WASTE PAPER

Submitted to

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ABBREVATIONS

BDL	-	Below Detectable Limit
BIS	-	Bureau of Indian Standards
BOD	-	Biological Oxygen Demand
CEC	-	Cationic Exchange Capacity
CES	-	Centre for Environmental Studies
COD	-	Chemical Oxygen Demand
CPCB	-	Central Pollution Control Board
dS	–	Deci Seimens
EC_e	–	Electrical Conductivity of water saturated soil paste.
EC	-	Electrical Conductivity
EPA	-	Environmental Protection Act
ESP	-	Exchangeable Sodium Percentage
ETP	-	Effluent Treatment Plant
GDP	-	Gross Domestic Product
Ha	-	Hectare
HLR	-	Hydraulic Loading Rate
IS	-	Indian Standards
Kg	-	Kilogram
KL	-	KiloLitre
m^3/d	–	Cubic metre Per Day
meq.	-	Milli Equivalent
MINAS	-	Minimal National Standards
NA	-	Not Available
NPC	-	National Productivity Council
PP	-	Precautionary Principle
RSC	-	Residual Sodium Carbonate
SAR	-	Sodium Absorption Ratio
SS	-	Suspended Solids
TDS	-	Total Dissolved Solids
TKN	-	Total Kjeldhal Nitrogen
TNAU	-	Tamil Nadu Agricultural University
TNPCB	-	Tamil Nadu Pollution Control Board
TNPL	-	Tamil Nadu Newsprint and Papers Limited
TPD	-	Tonnes Per Day
WWTP	-	Waste Water Treatment Plant
ZLD	-	Zero Liquid Discharge

CHAPTER 1

Background for the Study

1.1 General

The Indian Paper Industry accounts for about 1.6% of the world's production of Paper and Paperboard. The estimated turnover of the industry is Rs.25,000 crores (approximately) and its contribution to the exchequer is around Rs.2918 crores. The industry provides employment to more than 0.12 million people directly and 0.34 million people indirectly. The paper mill uses a variety of raw materials namely viz. wood, bamboo, recycled paper / fibre, bagasse, wheat straw, rice husk, etc. Approximately 35% are based on chemical pulp, 44% on recycled fibre and 21% on agro residues.

With added capacity of approximately 0.8 million tonnes during 2007-08, the operating capacity of the industry currently stands at 9.3 million tonnes. During this fiscal year, domestic production of paper and paper board is estimated to be 7.6 million tonnes. The overall paper consumption (including newsprint) has become 8.86 million tonnes and the percapita consumption is 8.3 kg. During the period 2000-07, newsprint, writing and printing, container board, carton board and others registered a growth of 13%, 5%, 11%, 9% and 1% respectively. The GDP has grown on an average of 6.7 over the last few years.

India is the fastest growing market for paper globally and the paper consumption is estimated to be 13.95 million tonnes by 2015-16. The Indian pulp and paper industry at present is very well developed and established. Paper sector is dominated by small and medium size units. Number of mills of capacity 50,000 tonnes/annum or more is not more than 25. Less than half a dozen mills accounts for almost 90% production of newsprint in the country (Source: Indian Paper Manufacturers Association).

1.2 Paper Recycling Units in Tamil Nadu

Paper recycling is the process of recovering of waste paper and remaking into new paper products. Paper suitable for recycling is called scrap paper and it includes paper trimmings, old magazines, old telephone directories, old newspaper, residential mixed paper, old corrugated container, printed sheets and cuttings, old books, ledgers, etc. Paper recycling units are doing processing of secondary fibres and they are also known as recovered/fibre industries. In India about 8,50,000-10,00,000 tonnes of waste paper is being currently recovered annually.

In Tamilnadu, 18 large-scale units, 29 medium scale units and 139 small-scale units are involved in manufacturing paper products in Paper Recycled Units. The various paper products manufactured in the industry include writing and printing paper, newsprint, craft and duplex boards and paperboards. These units fall under Orange category. The total water consumption in all the 186 units is 16,632 KL and total trade effluent generated is 15,190 KL daily (Source:TNPCB)

An inventorisation of Paper Units manufacturing Writing and Printing Paper from waste paper in Tamil Nadu was carried out with the assistance from TNPCB. About 32 units have responded to the questionnaire in which, 21 units are found to be involved in manufacturing either writing and printing paper alone or in combination with other paper products such as craft and duplex boards, newsprint and paper boards. The list of the industries is furnished in Table 1.1. The first unit manufacturing writing and printing paper from waste paper was established in the year 1965 in Dindigul district and this industry is operating for more than 40 years. As per the data furnished, 12 units in Dindigul district, 5 units in Erode district, 1 unit in Thirunelveli district, 1 unit in Coimbatore district, 1 unit in Tirupur distirct and 1 unit in Kancheepuram district are involved in manufacturing writing and printing paper alone or in combination with other paper products from waste papers. The production capacities of the units are found to be in the range of 10-80 TPD.

The quantities of total fresh water consumption in all the 21 units are found to be in the range of 174 to 3685 m^3/d. The quantities of total wastewater generation of the above units are found to be in the range of 150 m^3/d to 2350 m^3/d. Most of the units are discharging either the

entire full quantity or partial quantity of the effluent in their own lands for irrigation. The land area for irrigation is in the range of 11.2 hectares to 160 hectares. Various trees (eg. Coconut, Eucalyptus, Casuarinas, Mango, Teak, Tamarind and Subabul trees) are grown and various crops (eg. Paddy, Sugarcane, Banana, etc.) have been cultivated using the industrial effluents. The units are utilizing the effluent on land for irrigation for about 10-40 years. About 9 units are practicing land irrigation of the effluent for 10-20 years and about 8 units are practicing land irrigation for over 20 years period.

1.3 Scope and Objectives of the study

For small Pulp and Paper industry, standards have been provided by CPCB for discharge into inland surface water and onland (Table 1.2). By suspecting the continuous application of treated effluent on land may have an adverse impact on the soil and ground water quality, TNPCB is of the view that the paper units manufacturing writing and printing paper from waste paper should completely recycle their effluent after treatment for ensuring zero liquid discharge. In this context, the TNPCB has mandated the Centre for Environmental Studies, Anna University, Chennai to conduct a study on 'Technical feasibility of Complete Recycling of Treated Trade Effluent by the Paper Units which manufacture Writing and Printing Paper from Waste Paper'. The scope of the study includes the following three aspects:

- Whether the ZLD arrangement for discharging treated trade effluent in the paper industry is the most technically feasible clean arrangement (or) whether 100% reuse of backwater is not technically feasible.
- Whether ETP discharges, after appropriate treatment through activated sludge process will be injurious to ground water and cultivation of crops and
- Whether continued discharge of treated effluent in waste paper industry can result in ground water and soil pollution over a period of time.

Table 1.1 List of Units Manufacturing Writing & Printing Paper from Waste Papers in Tamil Nadu

Sl. No.	Name of the Industry	Taluk/District	Year of Establishment
1.	Amaravathi Sri Venkatesa Paper Mills Limited	Palani Taluk/Dindigul District	1985
2.	Amaravathi Sri Venkatesa Paper Mills Limited - Unit II	Palani Taluk/Dindigul District	1965
3.	Amaravathi Sri Venkatesa Paper Mills Limited – Unit-III	Palani Taluk/Dindigul District	1973
4.	V.G.Paper and Boards Limited	Palani Taluk/Dindigul District	1987
5.	Vishnuvardhan Paper Mills Private Limited –Unit-II	Palani Taluk / Dindigul District	1985
6.	Rajalakshmi Paper Mills Limite	Palani Taluk / Dindigul District	1980
7.	GVG Paper Mills Private Limited	Palani Taluk / Dindigul District	1991
8.	GVG Paper Mills Private Limited-Unit-III	Palani Taluk / Dindigul District	1986
9.	Danalakshmi Paper Mills Private Limited	Nilakottai Taluk / Dindigul District	1982
10.	Servalakshmi Paper and Boards Private Limited	Nilakottai Taluk / Dindigul District	1986
11.	Sri Hari Krishna Papers Private Limited	Palani Taluk / Dindigul District	1990
12.	Vijayalakshmi Paper Mills	Nilakottai Taluk / Dindugal District	1990
13.	M/s.Sam Turbo Industry Limited	Sathyamangalam Taluk / Erode District	1997
14.	M/s.Sudirman Paper (P) Limited	Sathyamangalam Taluk / Erode District	2008
15.	M/.Sri Sakthi Papers India (P) Limited	Sathyamangalam Taluk / Erode District	2005
16.	M/s.Aaditiya Aswin Paper Mills Private Limited	Sathyamangalam Taluk / Erode District	2007
17.	M/s.Karthikeya Paper & Boards Limited	Sathyamangalam Taluk / Erode District	1997
18.	M/s.Sun Paper Mill Limited	Tirunelveli District	1964
19.	Sri Sudarsan Paper Mills Limited,	Metupalayam Taluk / Coimbatore District	1991
20.	V.G.Paper and Boards Limited Unit-II	Udumalpet Taluk / Tirupur District	1997
21.	M/s.Cholan Paper and Board Mills Limited	Maduranthagam Taluk / Kancheepuram Distric	1989

Table 1.2 Small Pulp & Paper Industry: Standards for Liquid Effluents (CPCB)

Mode of Disposal	Parameter	Concentration not to exceed mg/L (except for pH and SAR)
Inland Surface Water	pH	5.5 to 9.0
	Suspended Solids, mg/L	100
	BOD at 27°C, 3 days, mg/L	30
Land	pH	5.5 to 9.0
	Suspended Solids, mg/L	100
	BOD at 27°C, 3 days, mg/L	100
	Sodium Absorption Ratio	26

(Source: EPA Notification S.O.64(E) dt. 18th Jan, 1998)

Small Pulp & Paper Industry: Wastewater Discharge Standards*

Category	
A: Agrobased	200 cum/tonne of paper produced
B: Waste Paper Based	75 cum/tonne of paper produced

* The agrobased mill to be established from January 1992 will meet the standards of 150 cum/tonne of paper produced.

** The waste paper mills to be established from January 1992 will meet the standards of 50 cum/tonne of paper produced.

CHAPTER 2

Paper Units Manufacturing Writing and Printing Paper from Waste Paper in Tamil Nadu

2.1 Raw Materials used

The Paper Recycling Units are using waste papers of varying grades as raw materials. The units use waste paper grade according to the paper quality of their product. The mixture of different paper types are sorted and sorted paper is baled. The units receive both locally available and imported waste papers. At first, the bales are opened and large foreign objects and many extraneous materials are readily removed (Fig.2.1 & 2.2).

2.2 Manufacturing Process

The various chemicals used in the manufacturing process include deinking chemicals (optional), sizing chemicals, bleaching chemicals (optional), whitening agent (optional), dyes (optional), etc. The details of production and raw materials and other chemicals used in the industries are presented in Table 2.1. The basic processes in manufacturing writing and printing paper from waste paper include pulping process, cleaning and screening, deinking (optional), thickening, refining, bleaching (optional) and paper making process (Table 2.2). The Table 2.3 presents the manufacturing process of all the 21 units.

In pulping process, the raw material (waste papers) is fed into high consistency pulper through a conveyor (Fig. 2.3) in which waste paper is mechanically slushed with addition of water (Fig. 2.4). Deinking, bleaching and stabilizing chemicals are added in the pulper itself. After pulping, the pulp is transferred to a storage tank through a coarse screen to remove large sized foreign materials like plastic, rubber, metal strips etc. It is then passed through high density cleaner and another set of screens to a storage tower, in which fine foreign materials are removed from the pulp (Fig. 2.5). The pulp is then taken to flotation cell, where deinking takes place and the deinked pulp is taken to a storage tower. The pulp is then cleaned through three stage centri screen to remove specks, dots etc. Then the pulp is thickened and stored and transferred to the

refiner. In refiners, mechanical modification of the fibres takes place to develop bonding surface uniformity and other physical characters during paper making. Finally the pulp is charged to paper machine for paper making.

The paper machine consists of headbox (back water system), wire part, press part, dryer part and calendaring. In the back water system, the pulp slurry with 3 to 5% consistency is fed to the fan pump along with back water drained in the wire part during the paper formation. The pulp becomes a slurry of 0.5 – 0.8% of consistency, then it is cleaned by centri cleaners to remove all dirt. The lean pulp slurry is then passed through a pressure screen to the machine head box. In the machine head box, the pulp is injected in the form of jet over the wire uniformly to form the paper (Fig. 2.6). The excess water is gradually removed by gravity and then by vacuum in the wire part. This white water is recycled in the back water system.

The paper web from the wire part is transferred to the press part. In the press part, the water is squeezed out of paper and then the paper web is transferred to dryer section where it is dried over the drying cylinders by indirectly heating with steam from inside (Fig. 2.7). The paper after drying is passed through highly polished calendar rolls to impart smoothness, gloss and flatness to the paper. The paper is then wound in a roll and it is rewound into smaller width to meet the end use (Fig. 2.8). Fig. 2.9 illustrates the basic flow chart of recovered pulp processing unit.

2.3 Water Consumption in Waste Paper Recycling Units

Paper Recycling Units use large quantities of water for manufacturing process. Water is required for stock preparation (pulping, deinking, screening and cleaning) and for paper making process (mixing chest, paper machine shower). In addition, water is required for cooling water for cylinder / calender, floor washing, boiler and domestic purposes. Table 2.4 presents the details of fresh water consumption and wastewater generation in waste paper recycling units in Tamil Nadu. The quantity of fresh water consumption in the paper recycling units is found to be in the range of 174-3685 m^3/day. The unit fresh water consumption is found to be in the range of 6-81m^3/t. The water consumption depends upon type of final product, type of production process and level of closed water system in the units.

2.3.1 Water Demand in the Paper Units

The water demand details of the paper units are presented in Tables 2.5 and 2.6. The fresh water consumption is found to be highest in paper making shower in almost all the units. The fresh water consumption for paper making shower is found to be in the range of 46-73%.

2.3.2 Closed Water Systems in Manufacturing Process

In order to reduce the fresh water consumption, certain units are operating closed water systems in the manufacturing process. A large amount of water is recycled for minimizing the fresh water consumption. It is difficult to define handling of water in a closed system, since no two units are alike in their operation. It is observed that the units are recycling white water (i.e. water drained in the paper making machine) to stock preparation (Pulper, Deinking plant, Cleaners and Screens) and for machine showers in the paper making machine. The closed water systems in two paper units viz., M/s.Amaravathi Sri Venkatesa Paper Mills Limited, Dindigul and M/s.Danalakshmi Paper Mills Private Limited, Dindigul are presented in Fig.2.10 and 2.11. White water is recycled untreated as diluent to mixing chest or it is reused after clarification in the fibre recover unit (save-all) at specific locations in the process where high quality water requirements are to be met.

2.3.3 Water Quality Requirement for Paper Making

The principal qualities of water that determine its suitably for the paper units are colour, suspended solids, iron, manganese, hardness, excess dissolved organic matter and silica. Water having little or no colour is essential for manufacture of paper. Suspended solids become entangled in fibres and thus causing sparks and other imperfections in the finished product. Cellulose absorbs iron and yield yellow colour. Manganese will oxidize by chloride to permanganate that impart reddish colour to the fibres.

It is observed that the Paper recycling units in Tamil Nadu are using either river water (Amaravathi / Vaigai / Bhavani) or bore well water or combination of both as process water for production. It is reported by an industry that the quality of process water in terms of pH, TDS and Total hardness are 7.48, 250 mg/L and 150 mg/L respectively.

2.4 Wastewater Generation

A large quantity of wastewater is generated in manufacturing writing and printing paper from waste paper. The wastewater streams included excess white water, wastewater streams from screening and cleaning, deinking, cooling water for cylinder/calendar, boiler blow down, miscellaneous, floor washings and domestic wastewater. The wastewater generation from various units in a typical paper unit (M/s.Amaravathi Sri Venketasa paper mills limited) is presented in Fig.2.12. The quantities of wastewater generation in the paper units are found to be in the range of 150-2350m^3/d. The unit wastewater generation in the paper units in Tamil Nadu is found to be in the range of 5-70 m^3/T. (Source: TNPCB).

Table 2.1 Production details of Units manufacturing Writing & Printing Paper from Waste Papers in Tamil Nadu

Sl. No.	Name of the Industry	Category	Production capacity (TPD)	Products manufactured	Raw materials and other chemicals used
1.	Amaravathi Sri Venkatesa Paper Mills Limited	Medium	50	News print and writing paper	Waste Paper, Deinking chemicals, Sizing and Bleaching chemicals
2.	Amaravathi Sri Venkatesa Paper Mills Limited - Unit II	Medium	25	Printing and writing paper	
3.	Amaravathi Sri Venkatesa Paper Mills Limited – Unit-III	Medium	25	Printing and writing paper	
4.	V.G.Paper and Boards Limited	Medium	35	News print, and Printing and Writing paper	Waste Paper, Deinking chemicals, Sizing, Bleaching
5.	Vishnuvardhan Paper Mills Private Limited – Unit-II	Medium	20	Printing and writing paper	Waste Paper and Sizing chemicals
6.	Rajalakshmi Paper Mills Limited	Medium	25	Writing & Printing paper	Waste Paper, Deinking, Sizing and Bleaching chemicals
7.	GVG Paper Mills Private Limited	Medium	60	Writing and printing paper, News print	100% wastepaper (Recycled) Chemicals: (Dynazyme, Dynasurf, Sodium silicate, Hydrogen Peroxide, Defoamer, caustic soda) Dyes: (Auromine "0", Methyl violet, Rhodamine)
8.	GVG Paper Mills Private Limited Unit-III	Medium	50	Writing and printing paper	100% wastepaper (Recycled) Chemicals: (AkD, Whitening Agent, Sodium Hypo, Defoamer, Caustic soda) Dyes: (Auromine "0", Methyl violet, Rhodamine, DF Scarlet, Methyl Blue, Methyl Green, Sun Flower Yellow)
9.	Danalakshmi Paper Mills Private Limited	Medium	60	Paper and Paper boards	Waste Paper 100%
10.	Servalakshmi Paper and Boards Private Limited	Medium	60	Paper and Paper boards	Waste Paper 100%

Table 2.1 Contd...

11.	Sri Hari Krishna Papers Private Limited	Medium	80	Writing & Printing Paper, News Print, Kraft and Duplex Boards	100% wastepaper (Recycled) Chemicals: (AkD, Whitening Agent, Sodium Hypo, Defoamer, Sodium silicate, Hydrogen peroxide) Dyes: (Auromine "0", Methyl violet, Rhodamine, Sun Flower Yellow)
12.	Vijayalakshmi Paper Mills	Medium	30	Paper and Paper boards	Waste Paper 100%
13.	M/s.Sam Turbo Industry Limited	Orange/ Large	33.4	Writing & Printing Paper	White Waste Paper, Alum, Rosin, Starch
14.	M/s.Sudirman Paper private Limited	Orange/ Large	33.4	Writing & Printing Paper	White Waste Paper, Alum, Rosin, Soap Stone Powder, Starch
15.	M/s Sri Sakthi Papers India private Limited	Orange/ Medium	20 (coated paper) 5 (kraft paper) 2.5 (unbleached Newsprint) 2.5 (brightness White paper)	Coated paper, kraft paper, Unbleached newsprint, Low brightness white paper	Finished white paper, White cutting waste, Box kraft waste, Clay and Starch solution, Rosin, Alum.
16.	M/s.Aaditiya Aswin Paper Mills Private Limited	Orange/ Small	10	Writing & Printing Paper	Waste White paper cuttings, Alum, Soap stone powder, Tinopal and Rosin.
17.	M/s.Karthikeya Paper & Boards Limited	Orange/ Large	30 (writing & printing paper) 3.4 (kraft paper)	Writing & Printing paper and Kraft Paper	Waste Paper, Alum, Rosin
18.	M/s Sun Paper Mill Limited	Large	75	Newsprint, Writing & Printing paper	Wood, Waste paper, Hosiery, Sodium Sulphite
19.	Sri Sudarsan Paper Mills Limited,	Small (orange)	20	Writing & Printing Paper (Second Grade Variety)	Indigenous Waste Paper, AKD, sodium Hypo Chlorite, Rhodamine, M.Violet, M.Green
20.	V.G.Paper and Boards Limited Unit-II	Large/ Orange	50	Newsprint and writing paper	Waste paper, Alum, Rosin, Starch, Silicate, M.Violet
21.	M/s Cholan Paper and Board Mills Limited	Orange/ Large	25	Writing and Printing Paper	Waste paper, Synthetic sizing agent, Starch, Sodium silicate, Hydrogen Peroxide, Caustic soda, M.violet, Optical whitening agent

Table 2.2 Basic Processes in Manufacturing Writing and Printing Paper from Waste Paper

Sl. No.	Manufacturing Process	Description
1.	Pulping	Chops the paper to smaller pieces.
2.	Cleaning and Screening	Centrifugal cleaning is spinning pulp slurry in a cleaner to remove materials denser than pulp fibres. Screens are used to remove contaminants that are larger than pulp fibres.
3.	Deinking (optional)	Removing printing ink by a combination of mechanical and chemical means.
4.	Thickening	Dewatering process.
5.	Refining	Mechanical modification of the fibres to develop bonding surface of the uniformity and other physical characters.
6.	Bleaching (optional)	To improve the brightness.
7.	Paper Making Process	
	a) Head box	To distribute pulp uniformly across a rapidly moving mesh screen.
	b) Wire part	Pulp stock will form as a sheet.
	c) Press part	To dewater by pressing.
	d) Dryer part	To remove moisture by steam.
	e) Calender	To get smooth surface.
	f) Pope reel	The paper is reeled in the pope reel.
	g) Rewinder	The paper rolls are taken to cutting machine for rewinder for further cuttings and finished products are packed.

Table 2.3 Manufacturing Process of the Paper Recycling Units

Sl.No.	Name of the Industry	Manufacturing process details
1.	Amaravathi Sri Venkatesa Paper Mills Limited	Pulper → Screens → Deinking → Centri cleaner → Slotted screen → Thickener → Refiner Centri cleaner → Paper machine
2.	Amaravathi Sri Venkatesa Paper Mills Limited - Unit II	Pulper → Screens → Deinking → Centri cleaner → Slotted screen → Thickener → Refiner Centri cleaner → Paper machine
3.	Amaravathi Sri Venkatesa Paper Mills Limited – Unit-III	Pulper → Screens → Deinking → Centri cleaner → Slotted screen → Thickener → Refiner Centri cleaner → Paper machine
4.	V.G.Paper and Boards Limited	Pulper → Screens → Deinking → Centri cleaner → Slotted screen → Thickener → Refiner Centri cleaner → Paper machine
5.	Vishnuvardhan Paper Mills Private Limited – Unit-II	Hydro pulper → HD cleaner → Coarse screen → Thickner → Refiners → Machine chest → Centri cleaners → Paper Machine → Cutting Machine → Finishing house
6.	Rajalakshmi Paper Mills Limited	Hydro pulper → HD cleaner → Coarse screen → Thickner → Refiners → Machine chest → Centri cleaners → Paper Machine → Cutting Machine → Finishing house
7.	GVG Paper Mills Private Limited	Hydro pulper → HD cleaner → Coarse screen → Thickner → Refiners → Machine chest → Centri cleaners → Paper Machine → Cutting Machine → Finishing house
8.	GVG Paper Mills Private Limited Unit-III	Chemicals → Storage chest → HD → Storage chest → screens → storage chest → Deinking → storage chest → Thickener → Dispersion → Refiners → Fan pump
9.	Danalakshmi Paper Mills Private Limited	Chemicals → Storage chest → HD → Storage chest → screens → storage chest → Deinking storage chest → Thickener → Dispersion → Refiners → Fan pump
10.	Servalakshmi Paper and Boards Private Limited	Chemicals → Storage chest → HD → Storage chest → screens → storage chest → Deinking → storage chest → Thickener → Dispersion → Refiners → Fan pump

Table 2.3 – Contd...

11.	Sri Hari Krishna Papers Private Limited	Chemicals → Storage chest → HD → Storage chest → screens → storage chest → Deinking → storage chest → Thickener → Dispersion → Refiners → Fan pump → Centri cleaner → screen → Head box → wire part → press part → Dryer → calendar → rope reel → rewinder → finishing
12.	Vijayalakshmi Paper Mills	Chemicals → Storage chest → HD → Storage chest → screens → storage chest → Deinking → storage chest → Thickener → Dispersion → Refiners → Fan pump → Centri cleaner → screen → Head box → wire part → press part → Dryer → calendar → rope reel → rewinder → finishing
13.	M/s.Sam Turbo Industry Limited	Hydro pulping → Cleaning → refining → wire making → pressing → Glazing & winding
14.	M/s.Sudirman Paper (P) Limited	Hydro pulping → Cleaning → refining → wire making → pressing → Glazing & winding
15.	M/.Sri Sakthi Papers India private Limited	Hydro pulping → Cleaning → refining → wire making → pressing → Glazing & winding
16.	M/s.Aaditiya Aswin Paper Mills Private Limited	Hydro pulping → Cleaning → refining → wire making → pressing → Glazing & winding
17.	M/s.Karthikeya Paper & Boards Limited	Hydro pulping → Cleaning → refining → wire making → pressing → Glazing & winding
18.	M/s.Sun Paper Mill Limited	Not available
19.	Sri Sudarsan Paper Mills Limited,	Not available
20.	V.G.Paper and Boards Limited Unit-II	Pulp preparation → Purifier → Spectro screen → Deinking → Centri cleaner → Vertical screening → Thickening → dispenser → paper machine → drier → calendaring → cutting machine → fin
21.	M/s.Cholan Paper and Board Mills Limited	Not available

Table 2.4 Water Consumption and Wastewater Generation in the Paper Units

Sl. No.	Name of the Industry	Source of water for process	Quantity of Fresh water consumption (m^3/d)	Unit Fresh Water consumption (m^3/tonne)	Quantity of wastewater Generation (m^3/d)	Unit wastewater generation (m^3/tonne)	Quantity of effluent used for land irrigation (m^3/d)
1.	Amaravathi Sri Venkatesa Paper Mills Limited	River Amaravathi	1100	22	1023	20	2373 (Common to units 1, 2, 3)
2.	Amaravathi Sri Venkatesa Paper Mills Limited - Unit II	River Amaravathi	700	28	650	26	
3.	Amaravathi Sri Venkatesa Paper Mills Limited – Unit-III	River Amaravathi	750	30	700	28	
4.	V.G.Paper and Boards Limited	River Amaravathi	875	25	807	23	807
5.	Vishnuvardhan Paper Mills Private Limited – Unit-II	River Amaravathi	300	15	272	14	272
6.	Rajalakshmi Paper Mills Limited	River Amaravathi	650	26	590	24	590
7.	GVG Paper Mills Private Limited	River Amaravathi, Bore and Well water	900	15	811	14	811
8.	GVG Paper Mills Private Limited - Unit-III	River Amaravathi, Bore and Well water	830	17	775	16	775
9.	Danalakshmi Paper Mills Private Limited	River Vaigai	1100	18	920	15	920
10.	Servalakshmi Paper and Boards Private Limited	River Vaigai	1550	26	1150	19	1150
11.	Sri Hari Krishna Papers Private Limited	River Amaravathi, Bore and Well water	1220	15	1125	14	1125
12.	Vijayalakshmi Paper Mills	River Vaigai	750	25	500	17	500
13.	M/s .Sam Turbo Industry Limited	River	2700	81	2350	70	NA
14.	M/s Sudirman Paper (P) Limited	River (well in the river)	532	16	500	15	Reused
15.	M/s Sri Sakthi Papers India (P) Limited	Well	174	6	150	5	Reused
16.	M/s Aaditiya Aswin Paper Mills Private Limited	Well	287	29	265	27	Reused
17.	M/s Karthikeya Paper & Boards Limited	Well	1250	37	1200	36	800
18.	M/s.Sun Paper Mill Limited	River	1818	24	1200	16	1200
19.	Sri Sudarsan Paper Mills Limited,	Bavani river	400	20	400	20	150
20.	V.G.Paper and Boards Limited Unit-II	Surface water from River Amaravati	3685	74	1650	33	1090
21.	M/s Cholan Paper and Board Mills Limited	Own Bore well	500	20	500	20	NA

Table 2.5 Details of Fresh Water Demand in Paper Recycling Units

Sl. No.	Description and Utility	Amaravathi Sri Venkatesa Paper Mills Limited		Amaravathi Sri Venkatesa Paper Mills Limited - Unit II		Amaravathi Sri Venkatesa Paper Mills Limited – Unit-III		V.G.Paper and Boards Limited		Rajalakshmi Paper Mills Limited	
		m^3/day	%	m^3/day	%	m^3/day	%	m^3/day	%	m^3/day	%
		Fresh Water									
1.	Paper Machine shower	755	69	480	69	515	69	607	69	475	73
2.	Cooling water for cylinder/calendar	85	8	55	8	60	8	70	8	75	12
3.	Pulp mill shower	115	10	75	10	75	10	95	11	-	-
4.	Miscellaneous	35	3	20	3	20	3	20	2	25	4
5.	Floor washings	25	2	15	2	15	2	15	2	20	3
6.	Boiler	80	7	50	7	55	7	63	7	50	8
7.	Domestic	6	1	5	1	4	1	5	1	5	0.7
Total		**1101**	**100**	**700**	**100**	**744**	**100**	**875**	**100**	**650**	**100**

Table 2.5 – Contd...

Sl.No.	Description	GVG Paper Mills Private Limited		GVG Paper Mills Private Limited Unit-III		Sri Hari Krishna Papers Private Limited	
		m^3/day	%	m^3/day	%	m^3/day	%
1.	Paper Machine (showers, headbox)	480	53	553	67	564	46
2.	Pulp makeup water	400	45	267	32	630	52
3.	Domestic	20	2	10	1	26	2
Total		**900**	**100**	**830**	**100**	**1220**	**100**

Sl.No.	Description	Danalakshmi Paper Mills Private Limited		Servalakshmi Paper and Boards Private Limited		Vijayalakshmi Paper Mills	
		m^3/day	%	m^3/day	%	m^3/day	%
1.	Domestic	15	1	6	1	15	3
2.	Wire part shower	415	39	450	60	240	40
3.	Press part shower	270	25	250	33	130	22
4.	Stock preparation	370	35	44	6	210	35
Total		**1070**	**100**	**750**	**100**	**595**	**100**

Sl.No.	Description	Vishnuvardhan Paper Mills Private Limited – Unit-II		Sri Sudarsan Paper Mills Limited	
		m^3/day	%	m^3/day	%
1.	Paper making process	300	100	370	93
2.	Domestic and Boiler	-	-	30	7
Total		**300**	**100**	**400**	**100**

Table 2.6 Details of Water Demand in the Paper Recycling Units

Name of the Industry	Category			Deinking		Total Quantity of Water Demand (m^3/day)	Fresh Water Consumption		Quantity of Recycled Water		Unit Fresh Water Consumption (m^3/tonne)
	Large	Medium	Small	With Deinking	Without Deinking		(m^3/ day)	%	(m^3/ day)	%	
Amaravathi Sri Venkatesa Paper Mills Limited		✔		✔		2705	1100	41	1605	59	22
Amaravathi Sri Venkatesa Paper Mills Limited - Unit II		✔		✔		1715	700	41	1015	59	28
Amaravathi Sri Venkatesa Paper Mills Limited – Unit-III		✔		✔		1879	750	40	1129	60	30
V.G.Paper and Boards Limited		✔		✔		2158	875	40	1283	60	25
Vishnuvardhan Paper Mills Private Limited – Unit-II		✔			✔	1283	300	23	983	77	15
Rajalakshmi Paper Mills Limited		✔			✔	1665	650	39	1015	61	26
GVG Paper Mills Private Limited		✔			✔	1274	900	71	374	29	15
GVG Paper Mills Private Limited - Unit-III		✔		✔		1277	830	65	447	35	17
Danalakshmi Paper Mills Private Limited		✔		✔		1590	1110	69	490	31	18
Servalakshmi Paper and Boards Private Limited		✔		✔		NA	1550	NA	NA	NA	26
Sri Hari Krishna Papers Private Limited		✔		✔		1653	1220	74	1277	26	15
Vijayalakshmi Paper Mills		✔		✔		1020	750	74	270	26	25
M/s .Sam Turbo Industry Limited	✔				✔	NA	2700	NA	NA	NA	81
M/s Sudirman Paper (P) Limited	✔				✔	NA	532	NA	NA	NA	16
M/s Sri Sakthi Papers India (P) Limited		✔			✔	NA	174	NA	NA	NA	6
M/s Aaditiya Aswin Paper Mills Private Limited			✔		✔	NA	287	NA	NA	NA	29
M/s Karthikeya Paper & Boards Limited	✔				✔	NA	1250	NA	NA	NA	37
M/s.Sun Paper Mill Limited	✔				✔	2492	1818	73	647	27	24
Sri Sudarsan Paper Mills Limited,			✔		✔	600	400	67	200	33	20
V.G.Paper and Boards Limited Unit-II	✔			✔		NA	3685	NA	NA	NA	74
M/s Cholan Paper and Board Mills Limited	✔				✔	NA	500	NA	NA	NA	20

Fig. 2.1 Waste Paper Bale

Fig. 2.2 Manual removal of Extraneous materials

Fig. 2.3 Conveyor towards Pulper

Fig. 2.4 High Consistency Pulper

Fig. 2.5 Screening

Fig. 2.6 Paper making Machine

Fig. 2.7 Calendering

Fig. 2.8 Final Product for end use
(Writing and Printing Paper)

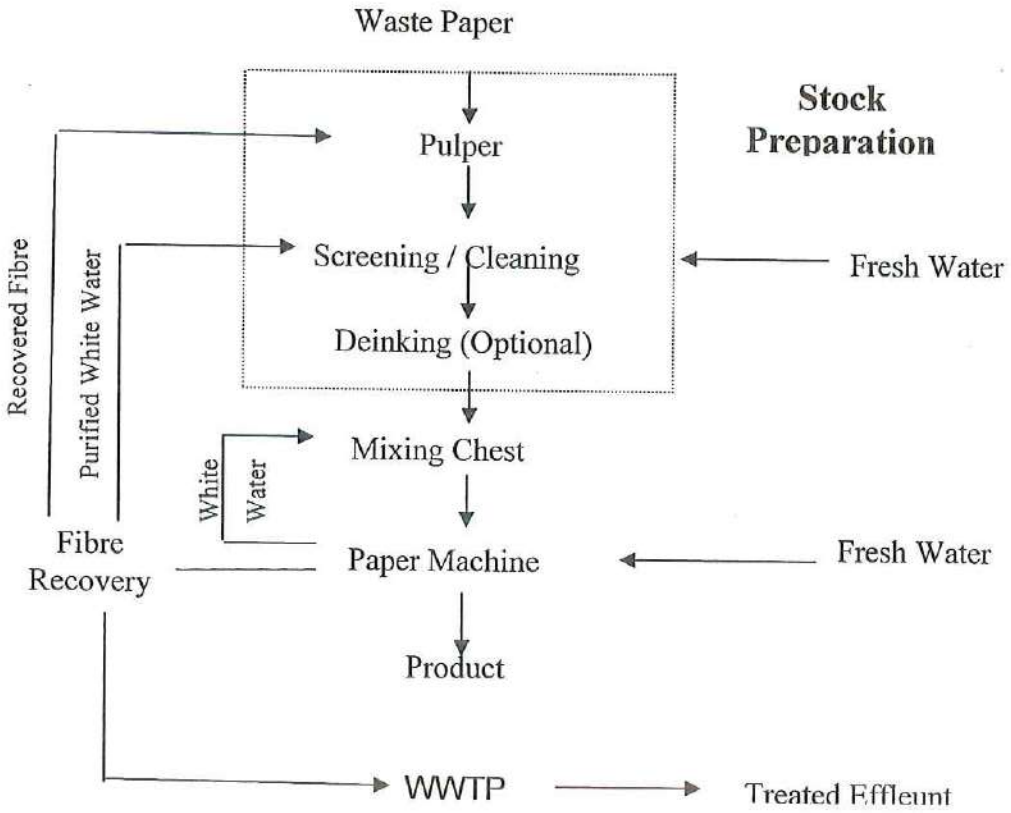

Fig. 2.9 Basic Flow Chart of Recovered Paper Processing Unit

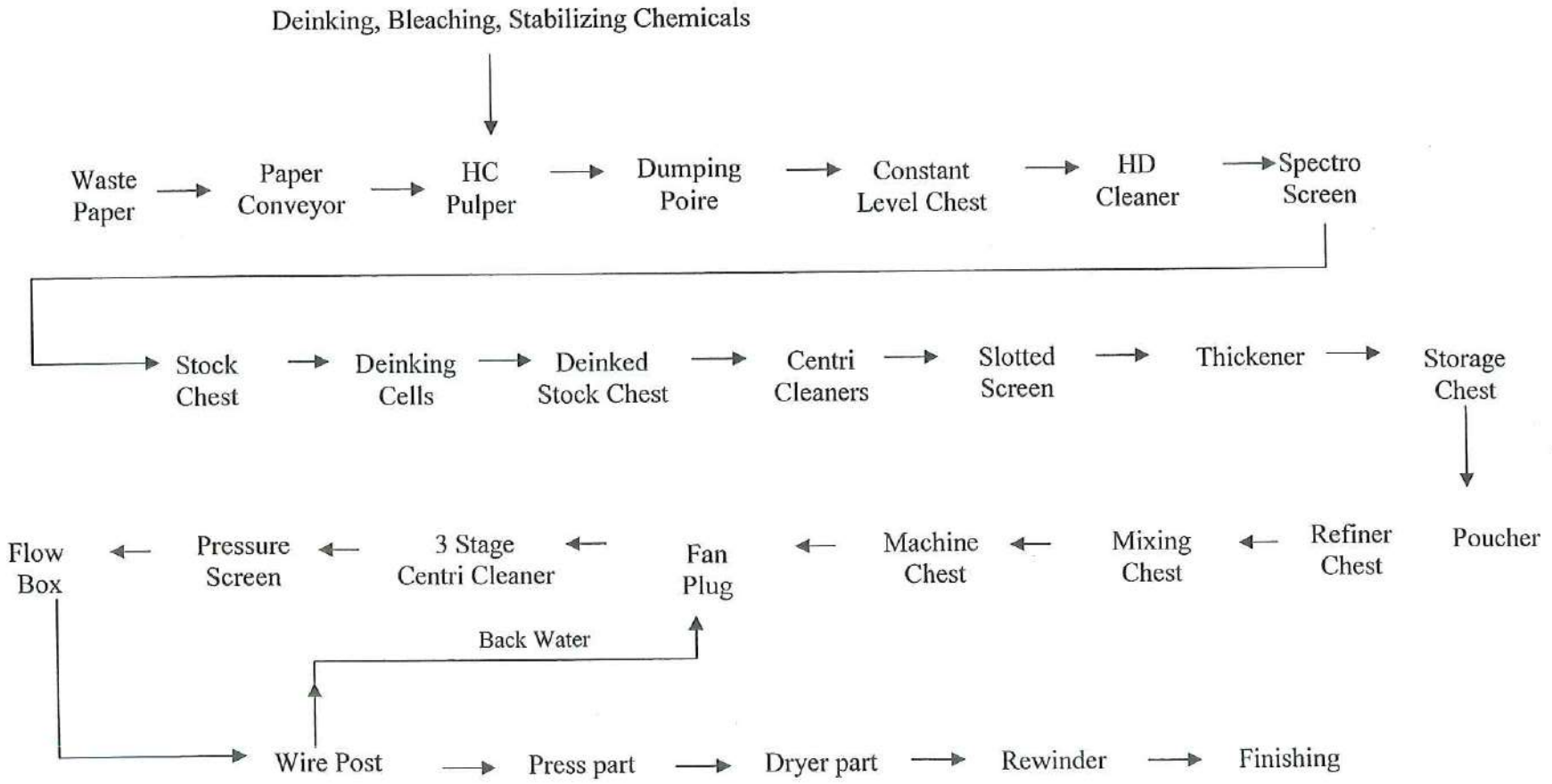

Fig. 2.10 M/s Amaravathi Sri Venkatesa Paper Mills Ltd. (Closed Water Sytem)

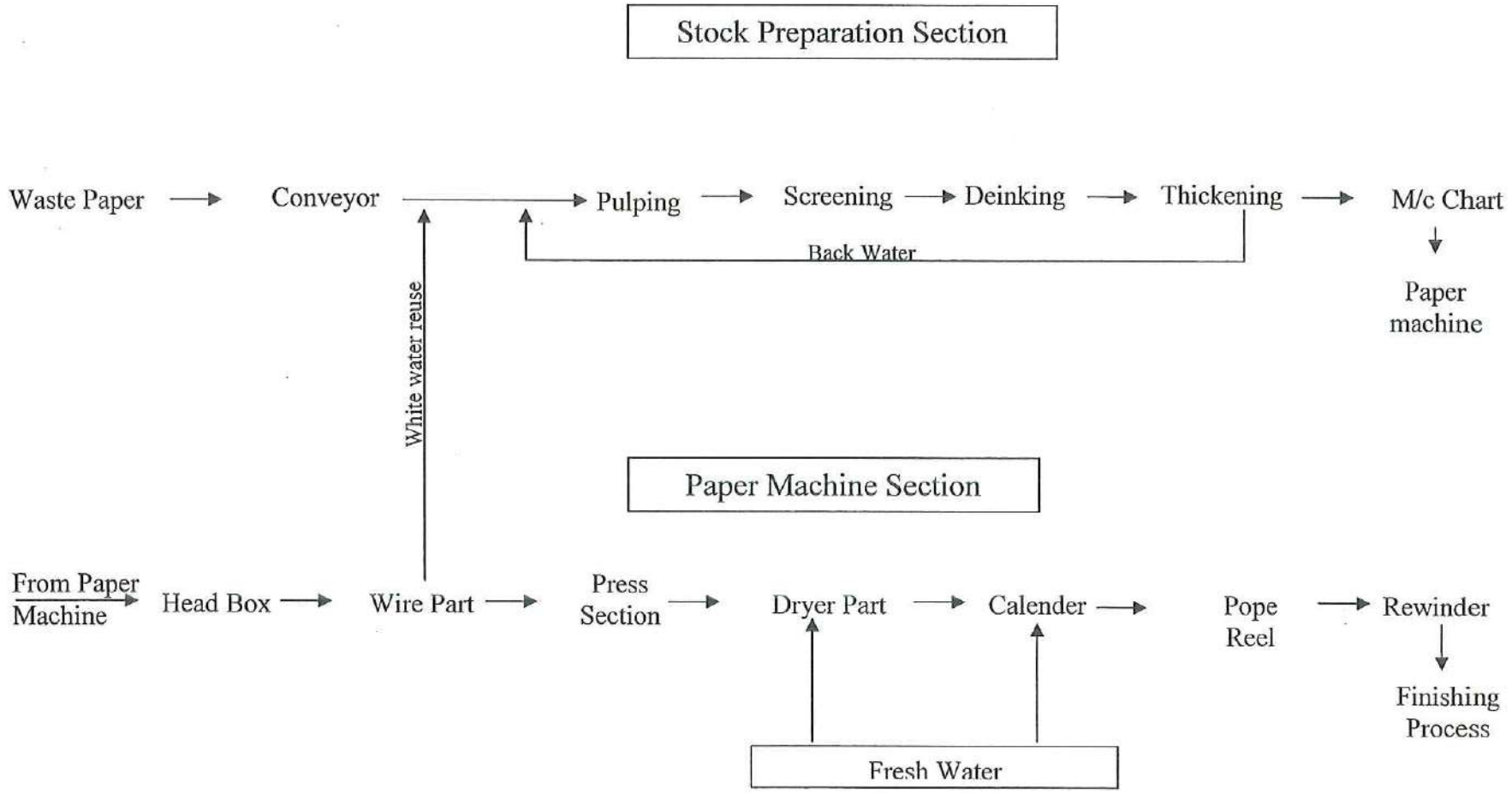

Fig 2.11 M/s Danalakshmi Paper Mills Limited (Closed Water Sytem)

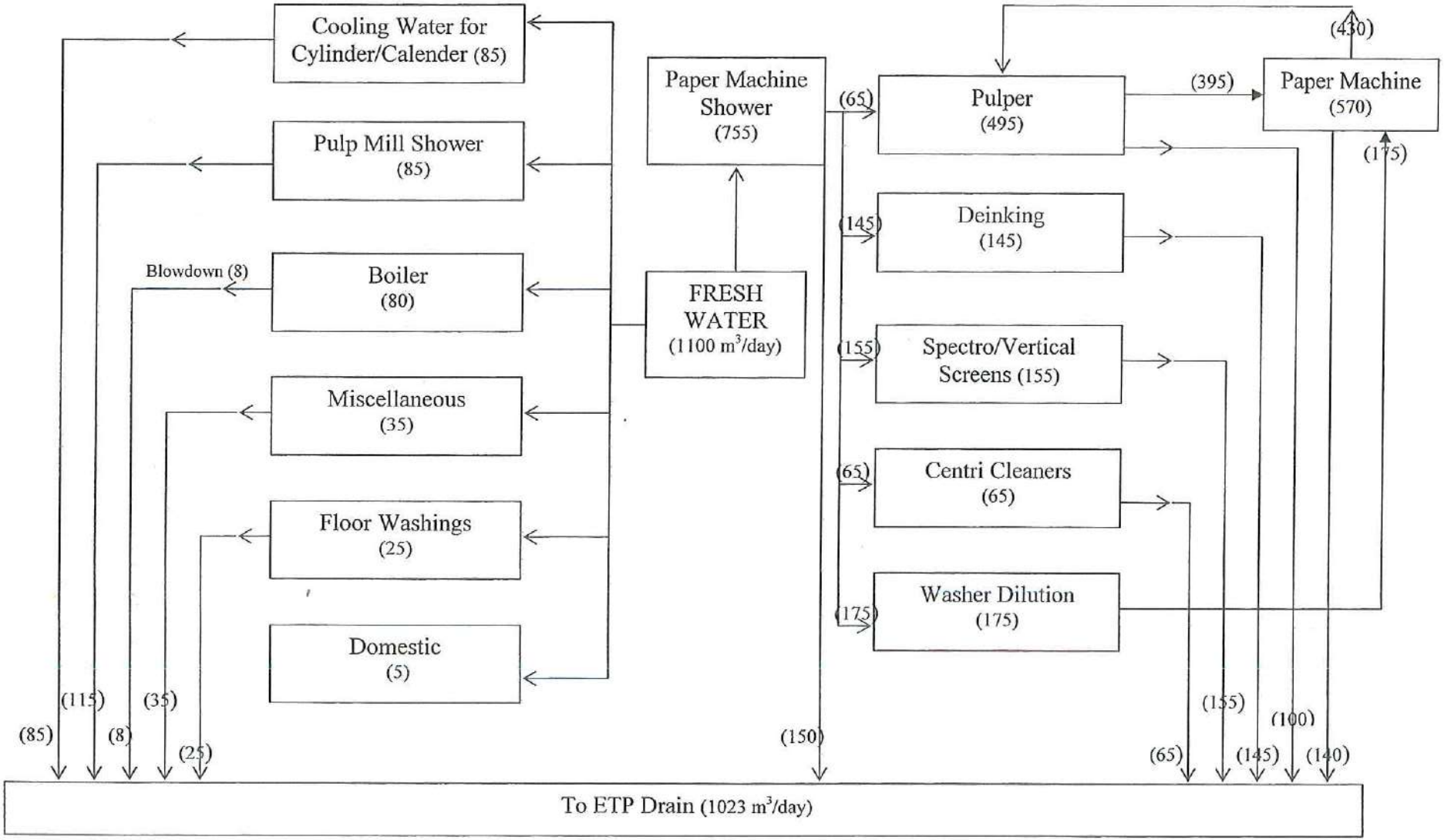

Fig 2.12 M/s Amaravathi Sri Venkatesa Paper Mills Limited (Wastewater Generation)

CHAPTER 3

Industrial Effluent Management in Study Units

3.1 Raw Effluent Characteristics

The raw effluent characteristics of eight paper recycling units are presented in Table 3.1 (Source: TNPCB). The major pollutants present in the wastewater include organics, suspended solids, dissolved solids and various inorganic ions. The raw effluent pH was found to be neutral. The BOD and COD varied in the range of 9 to 615 mg/L and 64 to 4320 mg/L respectively. Ingeneral, BOD and COD ratio less than 0.3 is an indicator of very poor biodegradability of wastewater. From the study, it was found that for the wastewater BOD/COD ratio varied in the range of 0.12 to 0.18 except for 2 units. This indicates the low biodegradability of wastewater. The TDS varied in the range of 158 to 3648 mg/L. Percent sodium was found to be in the range of 11 to 72.

3.2 Effluent Treatment Plants

A large quantity of wastewater is generated in manufacturing writing and printing papers from waste papers. The unit wastewater generation is found to be in the range of 150 to 2350m^3/day. In the inventorisation, all the 11 units have reported that effluent treatment plants are provided for treatment and reuse. It is observed that 13 units (12 in Dindigul and 1 in Thirunelveli) have taken 100% of the total effluent generated for land irrigation and 3 units have taken 38-67% of the total effluent for irrigation. Except one unit, all other units have furnished the treatment scheme.

The typical treatment processes include equalization and clarification as primary treatment, chemical precipitation or aerobic biological process or combination of both as main or secondary treatment and sand/activated carbon filtration as polishing treatment. For management of sludge, sludge drying beds have been provided. Six units have employed aerobic biological process as main treatment process, whereas 12 units have provided combination of chemical and biological treatment processes as main treatment process. The remaining two units have installed chemical treatment as main process. The details of effluent treatment schemes are presented in Table 3.2.

3.3 Standards for Discharge of Industrial Effluents

The Burea of Indian Standards (BIS) has laid down the first set of standards or tolerance limits for discharge of industrial effluents into Inland Surface Waters (IS: 2490 – 1974). These standards were referred as 'Effluent Standards' and they have been notified by GOI under the Environment (Protection) Rules, 1986 (Schedule VI, Rule 3-A). In addition to effluent standards, Minimal National Standards (MINAS) were incorporated in the Environment (Protection) Act, 1986. These standards were considered to be minimum standards for major polluting parameters that specific industry should achieve. The MINAS for Small Pulp and Paper Industry specified standards for discharge of liquid effluent into inland surface water and onland for irrigation. For discharge into inland surface water, standards have been specified for pH, SS and BOD. For discharge onto land, standards have been specified for pH, SS, BOD and sodium absorption ratio.

The Water (Prevention and Control of Pollution) Act, 1974 (section 17, Clause 3 of Subsection 1) empowers the Tamil Nadu Pollution Control Board (TNPCB) to lay down the effluent standards. Accordingly, TNPCB fixed up effluent standards for discharge of trade/sewage effluents (Revised order B.P.Ms.No.30 dt.21.12.1984) for 35 parameters. The National Standards for discharge of industrial effluents for relevant parameters applicable to this study are represented in Table 3.3. From Table 3.3, it is understood that pH, BOD, SS, TDS, chloride, sulphate, oil and grease, boron, percent sodium and residual sodium carbonate are important. The MINAS covers only four parameters which include Sodium Absorption Ratio (SAR).

3.4 Quality Requirements for Irrigation Waters

The Paper Recycling Units in Tamil Nadu are commonly using their wastewaters for irrigation. Traditionally, certain water quality criteria have been used to determine the suitability of the wastewaters for irrigation. The important physico-chemical parameters to determine the suitability of the wastewater for use in irrigation are pH, salinity, TDS, SS, organic compounds, inorganic ions, bicarbonate ions, boron and nutrients.

Salinity

High salinity in irrigation water may cause damage to crops. A general classification as to salinity hazard by TDS is as follows.

Sl.No.	Classification	TDS (mg/L)
1.	Water for which no determined effects are usually noticed	500
2.	Water that can have determined effects on sensitive crops	500-1000
3.	Water that can have adverse effects on many crops requiring careful management	1000-2000
4.	Water that can be used for tolerant plants on permeable soils with careful management	2000-5000

TNPCB and BIS have specified 2100 mg/L as maximum permissible limit for TDS for the trade effluents discharged onto land for irrigation.

Suspended Solids

Suspended solids (especially fibres) in applied effluents are important because they have a tendency to clog sprinkler nozzles and soil pores and to coat on land surface. The maximum limit for SS for discharge of effluent on land for irrigation has been fixed as 200 mg/L by TNPCB, whereas a more stringent standard of 100 mg/L has been fixed in MINAS (Pulp and Paper Industry) standards.

Organic Compounds

A high load of organic matter (as measured by BOD) will influence the length of the resting period for soil reaeration. These periods give the soil bacteria time to break down organic matter and to allow the water to drain. Aerobic conditions are thus restored as air penetrates into the soil. The maximum permissible limit for BOD for discharge of effluents into onland for irrigation has been fixed as 100 mg/L (27°C, 3 days) by TNPCB and MINAS, whereas BIS has permitted discharge of effluents of 500 mg/L BOD for onland irrigation.

pH

It is an indicator of the acidity or basicity of water. The normal pH range for irrigation water is from 6.5 to 8.4. pH values outside this range are a good warning that the water is abnormal in quality. The standard for pH has been fixed as 5.5 to 9.0 for discharge of trade effluents onland for irrigation by TNPCB, BIS and MINAS (Pulp and Paper Industry).

Inorganic Ions, SAR and Percent Sodium

Certain inorganic ions may affect the soil, the plants and the ground water. Sodium is an unique cation because of its effect on soil. Sodium enters into cation exchange relationships with calcium and magnesium adsorbed on the clay particles in the soil and tends to break down the clays. This is turn tends to reduce the soil porosity which is important for air and water movement. A 5-10% reduction in porosity can seriously impede growth. The concentrations of sodium, calcium and magnesium ions are related in an index called Sodium Absorption Ratio (SAR). The ratio measures the relative concentration of sodium to calcium and magnesium and it is defined by the following equation.

$$SAR = \frac{Na^{+}}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}}$$

where the cation concentrations are expressed in meq./L. A general classification as to sodium hazard by SAR is as follows.

SAR	Sodium hazard to soil
0-10	Low
10-18	Medium
18-26	High
Above 26	Very high

MINAS (Pulp and Paper Industry) has specified the standard for SAR as 26 for discharge of effluent onto land for irrigation. The maximum limit for Percent Sodium has been fixed as 60 by TNPCB and BIS. The percent sodium is calculated by the following equation.

$$\% \text{ Na} = \frac{Na^{+}}{(Ca^{2+} + Mg^{2+} + Na^{+} + K^{+})} \text{ X } 100$$

where the concentrations are expressed in meq./L.

Biocarbonate and RSC

Biocarbonate and Carbonate ions combined with calcium or magnesium will precipitate as calcium carbonate ($CaCO_3$) or magnesium carbonate ($MgCO_3$) when the soil solution concentrates in drying conditions. As calcium and magnesium are lost from soil water, the relative portion of sodium is increased resulting in increase in sodium hazard. This hazard is evaluated in terms of Residual Sodium Carbonate (RSC) and is defined by the following formula.

$$RSC = (CO_3^{2-} + HCO_3^{-}) - (Ca^{2+} + Mg^{2+})$$

Some typical values for irrigation waters are as follows.

Water Quality	RSC (meq/L)
Safe	<1.25
Marginal	1.35-2.5
Unsuitable	Over 2.5

The tolerance limit for RSC has been specified as 5 mg/L for discharge of effluent onto land for irrigation by TNPCB.

Boron

Boron is a phytotoxic substance, if it occurs in high concentration in irrigation waters. The tolerance limit for Boron has been specified as 2 mg/L for discharge of effluent onto land for irrigation by TNPCB and BIS.

Chlorides

Chlorides are said to have no effect on soils physical properties, but certain plants are sensitive to chloride ions. The permissible chloride concentration in irrigation water has been specified as 600 mg/L by TNPCB and BIS standard.

Sulphates

The maximum permissible limit for sulphates in irrigation water has been specified as 1000 mg/L by TNPCB and BIS standard.

3.5 Treated Effluent Quality in the study units

3.5.1 TNPCB Data

In Table 3.4, secondary data from TNPCB on the treated effluent quality (for parameters specified in TNPCB standards) for 10 industries are presented. In Table 3.5, both raw effluent and treated effluent characteristics for 3 industries are presented. The data regarding these 3 industries were a part of this study.

From Tables 3.4 and 3.5, the following inferences are made:

1. Since the industries treat the effluent to meet the standards for land disposal, the TDS levels in the effluent still remain at significantly higher levels (in many cases 2000 mg/L and more).
2. Similar is the argument regarding chloride, BOD/COD and SS which are still present in significant levels in the treated effluent.

3.5.2 CES Data

The Centre for Environmental Studies, Anna University have made a field visit to the paper recycling units in Palani Taluk/Dindigul District on 11.4.09. The manufacturing processes taking place in the industry and the effluent management practices have been studied. Raw and treated wastewater samples have been collected from two units. In addition, in order to study the ground water quality, well water samples have been collected from the irrigation area of the

industry. Also soil samples (4 nos.) have been collected from two locations in the irrigation area of each industry. Control samples for ground water and soil have also been collected. All above samples were brought to CES laboratory for analysis of various physico chemical parameters. The raw and treated effluent characteristics are presented in Table 3.6. The inferences made from this set of data are the same as that from TNPCB data (section 3.5.1).

3.6 Irrigation Practice

The details of the usage of the treated effluent for irrigation in the Paper Recycling units are presented in Table 3.7.

Table 3.1 Characteristics of Raw Effluent in Paper Recycling Units (Source: TNPCB)

Parameters	Amaravathi Sri Venkatesa Paper Mills Limited, Palani			V.G.Paper and Boards Limited, Palani	GVG Paper Mills Private Limited, Palani		Sri Harikrishna Papers Private Limited, Palani
	3.6.08	16.12.08	23.1.09	3.6.08	9.4.08	23.1.09	9.4.08
pH	7.29	6.8	6.81	6.59	7.36	6.91	7.5
BOD, mg/L	135	123	180	615	28	278	28
SS, mg/L	264	148	198	1984	48	484	38
TDS, mg/L	338	2024	3648	1288	2578	1956	1708
Chloride, mg/L	65	615	460	645	795	340	415
Sulphate, mg/L	20	3	148	118	142	12	68
Oil & Grease, mg/L	8	17	12	14	1.6	19	1.6
% Sodium	41	11	41	68	72	63	66
COD, mg/L	960	816	1120	4320	240	1560	224
BOD/COD ratio	0.14	0.15	0.16	0.14	0.12	0.18	0.13

Table 3.1 Contd...

Parameters	Rajalakshmi Paper Mills Limited, Palani			Vishnuvardhan Paper Mills Private Limited – Unit-II, Palani	M/s. Sam Turbo Industry Limited, Erode	M/s Karthikeya Paper & Boards Limited, Erode
	3.6.08	**3.6.08**	**13.1.09**	**13.1.09**	**16.12.08**	**22.1.09**
pH	6.97	7.17	6.69	7.04	6.59	7.26
BOD, mg/L	330	9	141	78	152	594
SS, mg/L	956	14	252	108	620	4736
TDS, mg/L	1272	158	2372	2924	524	3024
Chloride, mg/L	467	30	695	1040	95	1090
Sulphate, mg/L	205	17	240	299	44	35
Oil & Grease, mg/L	16	1	18	8.4	3	26
% Sodium	51	50	-	-	-	67
COD, mg/L	2368	64	880	520	560	1072
BOD/COD ratio	0.14	0.14	0.16	0.15	0.27	0.55

Table 3.2 Effluent Treatment Schemes of Paper Recycling Units

Sl. No.	Name of the Industry	Effluent Treatment Processes
1.	Amaravathi Sri Venkatesa Paper Mills Limited	Equalisation tank, Chemical precipitation, Primary clarifier, aeration, Secondary clarifier
2.	Amaravathi Sri Venkatesa Paper Mills Limited - Unit II	
3.	Amaravathi Sri Venkatesa Paper Mills Limited – Unit-III	
4.	V.G.Paper and Boards Limited	Equalisation tank, Chemical treatment, Primary clarifier, Sand filter, Sludge drying bed
5.	Vishnuvardhan Paper Mills Private Limited – Unit-II	Treatment scheme not available
6.	Rajalakshmi Paper Mills Limited	Equalisation tank, Chemical treatment, Primary clarifier, Sand filter, Sludge drying bed
7.	GVG Paper Mills Private Limited	Screen, Equalisation tank, color removal system, primary clarifier, sludge drying bed, aerator tank, settling tank, sludge drying bed
8.	GVG Paper Mills Private Limited Unit-III	
9.	Danalakshmi Paper Mills Private Limited	Collection tank, Flash mixture, Clarifier. Aeration tank, secondary clarifier. Sludge drying bed
10.	Servalakshmi Paper and Boards Private Limited	Collection tank, Clarifier, aeration tank, ,clarifier, sand filter, sludge drying bed
11.	Sri Hari Krishna Papers Private Limited	Equalisation tank, Clarifier, aeration tank, secondary clarifier, polishing pond, colour removal system, sludge drying bed
12.	Vijayalakshmi Paper Mills	Collection tank, Clarifier, aeration tank, ,clarifier, sand filter, sludge drying bed
13.	M/s Sam Turbo Industry Limited	Collection tank, Dosing tank, Primary clarifier, Aeration tank, Secondary clarifier, Treated effluent sump, Activated Carbon Filter, Pressure sand filter, Sludge Drying bed
14.	M/s Sudirman Paper (P) Limited	Collection tank, Dosing tank, Primary clarifier, Aeration tank, Secondary clarifier, Treated effluent sump, Activated Carbon Filter, Pressure sand filter, Sludge Drying bed
15.	M/.Sri Sakthi Papers India (P) Limited	Collection tank, Dosing tank, Primary clarifier, Aeration tank, Secondary clarifier, Treated effluent sump, Activated Carbon Filter, Pressure sand filter, Sludge Drying bed
16.	M/s Aaditiya Aswin Paper Mills Private Limited	Collection tank, Dosing tank, Primary clarifier, Aeration tank, Secondary clarifier, Treated effluent, sump, Activated Carbon Filter, Pressure sand filter, Sludge Drying bed
17.	M/s Karthikeya Paper & Boards Limited	Collection tank, Dosing tank, Primary clarifier, Aeration tank, Secondary clarifier, Treated effluent sump, Sludge Drying bed
18.	M/s.Sun Paper Mill Limited	Primary clarifier, equalization tank, aeration tank, secondary clarifier, sludge drying bed
19.	Sri Sudarsan Paper Mills Limited,	Primary clarifier, equalization tank, aeration tank, secondary clarifier, sludge drying bed
20.	V.G.Paper and Boards Limited Unit-II	Primary clarifier, equalization tank, aeration tank, secondary clarifier, sludge drying bed
21.	M/s Sholan Paper and Board Mills Limited	Primary clarifier, equalization tank, aeration tank, secondary clarifier, sludge drying bed

Table 3.3 National Standards for Discharge of Industrial Effluents

Sl.No	Parameters	Tolerance limits for discharge of Trade Effluents into Onland for irrigation (TNPCB)	Tolerance limit for Industrial Effluents discharged Onland for irrigation purposes (IS:3307-1977)	MINAS Standards for discharge of liquid effluents for Small Pulp and Paper Industry for Onland (EPA Notification S.O.64 (E), dt. 18th January, 1998)
1	pH	5.5 to 9	5.5 to 9	5.5 to 9
2	BOD (mg/L)	100 (27°C, 3 days)	500 (20°C, 5 days)	100 (27°C, 3 days)
3	SS (mg/L)	200	-	100
4	TDS (mg/L)	2100	2100	-
5	Chloride (as Cl) (mg/L)	600	600	-
6	Sulphate (as SO_4) (mg/L)	1000	1000	-
7	Oil & Grease (mg/L)	10	10	-
8	Boron (as B) (mg/L)	2	2	-
9	% Sodium	60	60	-
10	Sodium Absorption Ratio	-	-	26
11	Residual Sodium Carbonate (mg/L)	5	-	-

Table 3.4 Treated Effluent Quality in Paper Recycling Units (Source: TNPCB)

Parameters	Amaravathi Sri Venkatesa Paper Mills Limited, Palani			V.G.Paper and Boards Limited, Palani	GVG Paper Mills Private Limited, Palani		M/s Sri Sakthi Papers India (P) Limited, Erode	M/s Sudirman Paper (P) Limited, Erode
	03.06.08	16.12.08	23.01.09	03.06.08	09.04.08	23.01.09	30.01.09	27.11.08
pH	6.9	6.89	6.65	6.4	8.7	6.6	6.69	3.25
BOD, (mg/L)	26	95	108	102	9	285	1062	120
SS, (mg/L)	12	28	166	188	14	496	248	112
TDS, (mg/L)	638	1898	3524	1342	578	2480	9168	1152
Chloride, (mg/L)	154	278	420	630	105	460	3998	298
Sulphate, (mg/L)	63	5	155	30	35	8	706	92
Oil & Grease, (mg/L)	2	13	7.2	6	<1	14	8	5
Boron, (mg/L)	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
% Sodium	23	15	20	66	51	48	91	NA
RSC, (meq./L)	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
COD, (mg/L)	216	640	768	742	64	1680	3480	822

Table 3.4 Contd...

Parameters	Sri Hari Krishna Papers Private Limited, Palani		Rajalakshmi Paper Mills Limited, Palani			Vishnuvardhan Paper Mills Private Limited – Unit-II, Palani	M/s Karthikeya Paper & Boards Limited, Erode	M/s.Sam Turbo Industry Limited, Erode	
	09.04.08	23.01.09	03.06.08	03.06.08	13.01.09	13.01.09	22.01.09	16.12.08	22.01.09
pH	7.62	6.58	6.89	6.41	6.94	7.15	6.74	6.42	7.17
BOD, (mg/L)	13	252	32	9	42	43	247	292	278
SS, (mg/L)	12	264	40	12	52	94	116	104	400
TDS, (mg/L)	1148	3990	878	142	2252	2820	1428	660	648
Chloride, (mg/L)	260	950	248	20	615	1035	500	120	95
Sulphate, (mg/L)	121	5	123	20	153	294	24	15	12
Oil & Grease, (mg/L)	<1	13	4	1	3.2	6.4	3	3	22
Boron, (mg/L)	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
% Sodium	74	45	48	55	52	48	64	NA	35
RSC, (meq./L)	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
COD, (mg/L)	88	1184	256	64	296	304	496	656	432

Table 3.5 Raw & Treated Effluent Characteristics of Paper Recycling Units, April-2009 (Source: TNPCB)

Parameters	GVG Paper Mills Private Limited, Palani		Sri Hari Krihsna , Palani		M/s.Karthikeya Paper & Boards Limited, Erode	
	16.4.09		16.4.09		16.4.09	
	Untreated (104)	Treated (105)	Untreated (106)	Treated (107)	Untreated (135)	Treated (136)
pH	6.95	7.02	6.65	6.46	4.32	7.20
BOD, mg/L	474	466	287	316	2034	28
SS, mg/L	1376	682	120	148	1248	34
TDS, mg/L	2064	2190	2442	2674	7578	2514
Chloride, mg/L	551	534	886	890	2084	315
Sulphate, mg/L	271	235	343	312	2668	1169
Oil & Grease, mg/L	9	8	6	7	10	4
Boron, mg/L	NA	NA	NA	NA	NA	NA
% Sodium	44	39	56	55	38	43
SAR	NA	NA	NA	NA	NA	NA
RSC, meq./L	NA	NA	NA	NA	NA	NA
COD, mg/L	1376	1440	1056	1408	7440	184
BOD/COD ratio	0.34	-	0.27	-	0.27	-

Table 3.6 Effluent Characteristics of Paper Recycling Units (Primary Data, CES)

Parameters	Industry A		Industry B	
	11.4.09		11.4.09	
	Untreated	Treated	Untreated	Treated
pH	7.03	7.60	7.40	7.78
BOD, mg/L	255	210	390	255
SS, mg/L	NA	NA	NA	NA
TDS, mg/L	2000	2568	1750	1755
Chloride, mg/L	950	1092	550	600
Sulphate, mg/L	50	60	125	80
Oil & Grease, mg/L	NA	NA	NA	NA
Boron, mg/L	Nil	Nil	Nil	Nil
% Sodium	28	36	28	26
SAR	2.6	3.8	2.8	2.3
RSC (meq.L)	Nil	Nil	Nil	Nil
Lead, mg/L	1.04	1.52	1.06	0.84
COD, mg/L	660	550	860	700
Potassium, mg/L	7	8	12	10
Sodium (mg/L)	190	290	230	170
Calcium, mg/L	240	360	360	240
Magnesium, mg/L	98	49	85	110
Total hardness, mg/L	1000	1100	1250	1050
EC (µS/cm)	3040	3890	2650	2660
BOD/COD ratio	0.39	-	0.45	-

Table 3.7 Irrigation Practices of Paper Recycling Units

Sl.No.	Name of the Industry	Land irrigation of effluent		
		No. of years of practice	Area (hectares)	Types of crops, Trees
1.	Amaravathi Sri Venkatesa Paper Mills Limited	24	151	Coconut, Eucalyptus
2.	Amaravathi Sri Venkatesa Paper Mills Limited - Unit II	43		
3.	Amaravathi Sri Venkatesa Paper Mills Limited – Unit-III	35		
4.	V.G.Paper and Boards Limited	22	17.4	Coconut, Eucalyptus
5.	Vishnuvardhan Paper Mills Private Limited – Unit-II	23	26.31	Coconut, Eucalyptus
6.	Rajalakshmi Paper Mills Limited	29	34.4	Coconut, Eucalyptus, Mango & Teak
7.	GVG Paper Mills Private Limited	18	81.28	Coconut, Casuarina, Tamarind
8.	GVG Paper Mills Private Limited Unit-III	13	NA	Coconut trees
9.	Danalakshmi Paper Mills Private Limited	27	39.29	Coconut, Paddy
10.	Servalakshmi Paper and Boards Private Limited	24	37.48	Coconut, Paddy
11.	Sri Hari Krishna Papers Private Limited	19	34.4	Coconut, Casuarina, Tamarind
12.	Vijayalakshmi Paper Mills	19	11.2	Coconut, Paddy
13.	M/s Sam Turbo Industry Limited	12	37.5	Sugarcane
14.	M/s Sudirman Paper (P) Limited	-	-	-
15.	M/s Sri Sakthi Papers India (P) Limited	-	-	-
16.	M/s Aaditiya Aswin Paper Mills Private Limited	-	-	-
17.	M/s Karthikeya Paper & Boards Limited	12	18	Trees, Sugarcane
18.	M/s Sun Paper Mill Limited	10	160	Eucalpytus, Subabul, Casuarina, Mangium
19.	Sri Sudarsan Paper Mills Limited,	18	16.2	Coconut, Banana. Mango
20.	V.G.Paper and Boards Limited Unit-II	11	45	Sugar cane, Eucaplytus trees, Coconut
21.	M/s Cholan Paper and Board Mills Limited	NA	NA	NA

CHAPTER 4

Assessment of Impact of Land Disposal on Ground Water Quality

4.1 Approach for the assessment

4.1.1 Past Ground Water Quality Data

In the Table 3.7, it is inferred that the disposal of treated effluent on land has been happening for periods ranging from 10-44 years. Discharge of industrial effluents on land will affect

1. Soil characteristics and
2. Ground Water Quality

which in turn will affect the growth of crops in the soil. The severity of the effect will depend on toxicity of the effluent, land environment characteristics and crop properties. In this chapter, an assessment of the impact of land disposal of the effluents is described.

For the purpose of this assessment, past data on the quality of water in the wells situated fairly close to the industrial units and monitored by Tamil Nadu Ground Water Department, were obtained from the Board. These wells were the nearest wells for which useful data are available (Due to shortage of time available for the study, extensive primary data could not be obtained). The secondary data included groundwater quality for 12 monitoring wells in Dindigul District, 7 monitoring wells in Erode District and 2 monitoring wells in Kancheepuram District. Only one monitoring well (Well No. HP1E16, Rajan Nagar village, Bhavani Sagar Block / Sathyamangalam Taluk / Erode District) was located in the same village of 4 paper recycling units. Another monitoring well (Well No. 13011A Padalam village Madurandagam Block / Taluk) was located within 3 km distance from a paper recycling unit in Kancheepuram District. All other monitoring wells are located at distances of 10 – 18 km from the industry premises.

The data obtained from the Board were in different format. An useful set of data was extracted from the source data and presented in a new format as in Table 4.1. The pH, TDS, % sodium and RSC were selected as the parameters of quality of water, since these were related to the irrigation potential of the water. Data from a total of 20 wells was used.

In Table 4.1, under each serial number, the well serving as the reference well, industries in the vicinity (real names not used but indicated as study units) and water quality are presented. For assessing the impact, water quality data for 2 different years with a significant time gap are used. A comparison of the quality for these 2 years is made to arrive at meaningful conclusions regarding the impact.

The following are the inferences made from Table 4.1:

1. Let us consider the quality of the well water in Sl.No.1 in Table 4.1. From a level of 692 mg/L in 1989, the TDS has increased to 2237 mg/L in 2008. Similarly, the % sodium has increased from 19 to 24. This trend is noticed in the case of wells in Sl. Nos. 2, 4, 5, 6, 7, 8, 10, 12, 13, 14, 16, 18 and 20.

2. Fourteen out of twenty wells considered for study, have shown decline in the water quality in terms of TDS and % sodium.

3. The exact causes for this deterioration in the well water quality can be assessed only by a detailed study. However, the industrial effluents discharge on land could be a contributing factor. It will be difficult to rule out this possibility, as the effluent has the potential to cause such a problem.

4. The increase in the TDS is alarming. In many cases, in about 10 years time, the TDS level has doubled. If this trend continues, the TDS will reach a level which will make the water unusable for irrigation in the next 10 years.

4.1.2 Present Status in Select Cases

In addition to the analysis of the trend in the quality of well water in the vicinity of the industries, the CES enumerated the well water quality in the irrigation area of 2 industries

(Industry A and B). A background well was also identified for comparison purposes. The data on the well water quality for all 3 wells are presented in Table 4.2. In addition, ground water quality for 28 samples in the irrigation area furnished by TNPCB is presented in Table 4.3.

From Tables 4.2 and 4.3, it is concluded that:

1. The wells in the irrigated area show high levels of TDS, chloride, sulphate and % sodium, when compared to the background levels.

2. This set of data further confirms the observations made in section 4.1.1.

TABLE 4.1 GROUND WATER QUALITY IN THE VICINITY OF INDUSTRIES

Sl.No.	GW Monitoring Well			Nearby Industries located at 10-15 km from the wells	Year	pH	TDS (mg/L)	% Sodium	SAR	RSC
	Well No.	Village Name	Block/Taluk/ District	No. of Units						
1	2	3	4	5	6	7	8	9	10	11
1	83537	Midapadi	Palani / Palani/ Dindugal	3 Units	1989	8.2	692	19	1.09	Nil
					2008	6.9	2237	24	2.47	Nil
2	83524	Neikaranpatti	Palani / Palani/ Dindugal	3 Units	1989	8.3	357	13	0.51	Nil
					2008	7.6	725	49	3.41	Nil
3	83525	Thalaiyuthu	Thoppanpatti / Palani / Dindugal	6 Units	1989	8.2	437	25	1.05	0.52
					2008	7.3	260	19	0.64	Nil
4	83540	Valasu	Palani/ Palani/ Dindugal	6 Units	1989	8.0	846	29	1.97	Nil
					2008	7.5	1385	36	3.26	Nil
5	83541	Kariyampatti	Palani/ Palani/ Dindugal	6 Units	1989	8.2	484	17	0.78	Nil
					2008	6.8	683	25	0.74	Nil
6	22008D	Melkaripatti	Palani/ Palani/ Dindugal	6 Units	1998	8.9	1091	52	4.89	Nil
					2008	8.2	3305	42	6.07	Nil
7	22017D	Thunbalapatti	Palani/ Palani/ Dindugal	6 Units	1998	8.6	696	37	2.25	Nil
					2008	8.0	967	31	1.76	Nil
8	22019D	Pallapatti	Nilakottai/ Nilagutty / Dindugal	2 Units	1999	8.0	493	46	0.95	Nil
					2008	7.6	1087	14	7.11	Nil
9	22022D	Sithargalnathan	Nilakottai/ Nilagutty / Dindugal	2 Units	2000	8.7	1098	65	0.65	Nil
					2008	8.1	402	15	4.26	Nil
10	22036D	Gullalagundu	Nilakottai/ Nilagutty / Dindugal	2 Units	2000	8.9	718	42	2.8	3.3
					2008	8.0	885	38	1.94	Nil
11	83022	Nilakottai	Nilakottai/ Nilagutty / Dindugal	2 Units	1989	8.4	1703	24		Nil
					2008	7.9	1320	47	2.0	Nil

Table 4.1 Contd..

Sl. No.	GW Monitoring Well			Nearby Industries located at 10-15 km from the wells	Year	pH	TDS (mg/L)	% Sodium	SAR	RSC
	Well No.	Village Name	Block/ Taluk/ District	No. of Units						
1	2	3	4	5	6	7	8	9	10	11
12	63017	Muddukandurai	Bhavani Sagar/ Satyamangalam/ Erode	2 Units	1991	8.2	315	19	0.82	Nil
					2008	7.5	1919	56	8.18	Nil
13	63019	Vinapalli	Bhavani Sagar/ Satyamangalam/ Erode	2 Units	1989	8.1	407	13	0.57	Nil
					2008	7.6	1078	55	5.25	Nil
14	63020	Shenbaga Pudur	Satyamangalam/ Satyamangalam/ Erode	4 Units	1989	8.5	269	34	1.4	0.55
					2008	8.0	282	12	0.4	Nil
15	63028	Chikara Sampalam	Satyamangalam/ Satyamangalam/ Erode	4 Units	1989	8.1	801	29	2.02	Nil
					2008	7.7	540	21	1.05	Nil
16	HP2E24	Ayyampalayam	Bavani Sagar / Satyamangalam / Erode	1 Unit	2001	8.5	732	96	-	Nil
					2008	7.0	1033	45	3.68	Nil
17	HP2E16	Ukkaram	Satyamangalam/ Satyamangalam/ Erode	4 Units	2001	7.7	1116	93	-	Nil
					2008	8.0	788	34	2.15	Nil
18	HP1E16	Rajan Nagar	Satyamangalam/ Erode	4 Units	2006	7.9	590	28	0.73	Nil
					2008	8.0	1121	45	3.76	Nil
19	230703	Padalam	Madurandagam / Madurandagam / Kancheepuram	1 Unit	1989	8.1	425	50	1.75	0.23
					1999	8.8	350	6	0.22	Nil
20	13011A	Madurandagam	Madurandagam / Madurandagam / Kancheepuram	1 Unit	1989	8.6	266	45	1.10	Nil
					2008	7.9	687	59	4.70	1.95

Table 4.2 Ground water Quality in the Irrigation Area of Paper Recycling Units (Primary Data, CES)

Sl.No.	Parameters	Industry A	Industry B	Background Well
		11.4.09	**11.4.09**	
1.	pH	7.90	7.44	7.26
2.	BOD, mg/L	15	10	BDL
3.	TDS, mg/L	5270	2920	1470
4.	Chloride, mg/L	2349	925	506
5.	Sulphate, mg/L	120	100	60
6.	Boron, mg/L	BDL	BDL	BDL
7.	% Sodium	22	26	15
8.	RSC, meq./L	Nil	Nil	Nil
9.	COD, mg/L	40	95	80
10.	Lead, mg/L	1.6	1.0	BDL
11.	Potassium, mg/L	14	16	7
12.	Sodium, mg/L	360	260	250
13.	Calcium, mg/L	760	360	200
14.	Magnesium, mg/L	207	159	159
15.	Total hardness, mg/L	2750	1550	1150
16.	EC (µS/cm)	7990	4420	2240

Table 4.3 Ground water Quality in the Irrigation Area of Paper Recycling Units (Source: TNPCB)

Parameters	Amaravathi Sri Venkatesa Paper Mills Limited, Palani							
	6.2.2007				10.7.2007			
	Well 1	Well 2	Well 3	Well 4	Well 1	Well 2	Well 3	Well 4
pH	7.54	7.80	7.77	7.40	7.07	7.20	7.31	6.99
TDS, mg/L	5984	6828	5088	3278	6704	7868	7742	3154
Chloride, mg/L	2470	2837	2064	1125	2422	2928	2908	1007
Sulphate, mg/L	1319	1166	697	510	1314	1306	1056	262
% Sodium	58	59	61	57	59	68	68	41
Total alkalinity, mg/L	340	380	280	340	210	310	330	250

Table 4.3 Contd...

Parameters	Rajalakshmi Paper Mills Limited, Palani		Vishnuvardhan Paper Mills Private Limited – Unit-II, Palani		V.G.Paper and Boards Limited, Palani	
	5.12.06	3.5.07	5.12.06	3.5.07	5.12.06	3.5.07
pH	7.7	7.49	7.29	6.64	6.96	7.14
TDS, mg/L	4928	4432	4804	4384	4268	3698
Chloride, mg/L	1536	1628	1228	1519	1331	1221
Sulphate, mg/L	541	499	429	509	615	384
% Sodium	41	NA	28	NA	48	NA
Total alkalinity, mg/L	380	380	290	410	450	430

Table 4.3 Contd...

Parameters	GVG Paper Mills Private Limited, Palani						
	12.2.07			5.1.07			8.4.09
	Well 1	Well 2	Well 3	Well 1	Well 2	Well 3	Well 1
pH	7.12	6.90	7.5	6.64	6.69	6.73	7.39
TDS, mg/L	4860	4008	5036	4740	4180	4690	2266
Chloride, mg/L	1271	1084	1459	1536	1350	1575	895
Sulphate, mg/L	1058	661	759	1042	822	986	353
% Sodium	47	36	26	57	45	32	39
Total alkalinity, mg/L	400	610	400	400	470	430	<0.0005

Table 4.3 Contd...

Parameters	Sri Hari Krishna Papers Private Limited						
	5.1.07			12.6.07			9.4.09
	Well 1	Well 2	Well 3	Well 1	Well 2	Well 3	Well 1
pH	7.31	6.54	6.95	7.36	7.06	7.38	6.75
TDS, mg/L	6096	3954	4204	6208	5864	5172	3080
Chloride, mg/L	2495	1785	1565	2336	2020	1941	996
Sulphate, mg/L	1077	564	844	1357	709	905	412
% Sodium	41	53	35	44	56	49	32
Total alkalinity, mg/L	420	480	410	350	430	350	-

CHAPTER 5

Assessment of Impact of Land Disposal of effluents on Soil Quality

5.1 Soil Properties

The soil properties (chemical characteristics) to be considered in irrigation are soil sodicity, soil salinity, soil pH, soil organic matter, Cations Exchange Capacity, nutrient levels and adsorption and fixation properties for various inorganic ions such as sodium, potassium, magnesium, calcium and hydrogen. The significance of important properties is explained in the following paragraphs.

Soil Sodicity

It refers to the amount of exchangeable sodium cations relative to other cations in the soil and is expressed in terms of exchangeable sodium percentage (ESP). Dispersion of soil or poor soil structure may be associated with sodicity. Exchangeable sodium acts as a mechanism for weakening the bonds of soil aggregates creating a soil with poor structure that can impede water and plant root movement into and through the soil. It is generally agreed that soils with an ESP of greater than 5 are at risk of showing the adverse structural impacts with sodicity. The soil sodicity can be expressed either as ESP or SAR. Sodium is one of the most studied elements because of its toxic effects both to soil texture and crop:

- High concentration of sodium disperses soil colloidal particles rendering the soil hard and resistant to water penetration.
- The build up of osmotic pressure in soil due to high sodium concentration causes difficulty in water absorption by plant roots. Plants are sensitive to varying degrees to soil salinity and when this exceeds a certain limit, their growth is impaired, thus lowering their productivity.

Soil Salinity

Soil Salinity refers to the amount of dissolved salts in the soil solution. Soil salinity levels are determined by measuring EC of soil suspension. The soluble salts are likely to be the cations (Na^+, K^+, Ca^{2+}, Mg^{2+}) and anions (Cl^-, SO_4^{2-}, HCO_3^-). Effluents may raise soluble salt levels to the extent that they impede plant growth and thereby increasing the potential for soil erosion. The concentration in the soil at which salt is hazardous varies with soil texture and plant species. Soil salinity is indicated as EC_e (Electrical Conductivity of water saturated soil paste) and expressed as dS/m.

Soil pH

Soil pH is a measure of the concentration of hydrogen ions in the soil. It is known to be related to the availability of plant micro and macro nutrients. For most plants, a range between 6-7.5 maximizes the availability of plant nutrients and hence the potential for plant growth.

Soil Organic Matter

Soils with a reasonably high level of organic matter (i.e. atleast 2% by weight) are desirable for effluent irrigation. Organic matter encourages soil microbial activity and increases cation exchange and water holding capacity.

Cation Exchange Capacity

The cation exchange capacity (CEC) of a soil is the total quantity of exchangeable cations it can retain on its adsorption complex at a given pH. Soils with high CEC have good soil structure. Addition of organic matter (which has a high CEC) may improve soils with a low CEC. Exchangeable cations in soil include Ca^{2+}, Mg^{2+}, K^+, Na^+, H^+ and Al^{3+}.

Soil Classification

'Normal' soils have EC values less than 4 dS m^{-1} and ESP values below 15%. Saline soils have EC_e values greater than 4 dS m^{-1} with an ESP less than 15%. Sodic soils have EC_e values less than 4 dS m^{-1} but ESP greater than 15%. Saline-sodic soils are a fourth category of salt-affected soils. These soils have both high EC_e (>4 dS m^{-1}) and high ESP (>15%).

In Table 5.1, the relation between soil properties and plant growth is presented.

Table 5.1 Soil properties and Plant growth

Property	Limitation			Restrictive feature
	Nil/Slight	Moderate	Severe	
ESP (0-40 cm)	0-5	5-10	>10	Structural degradation and water logging
ESP (40-100 cm)	<10	>10	-	Structural degradation and water logging
Salinity (EC_e) d S/m)	<2	2-4	>4	Excess salt may restrict plant growth
Soil pH	>6-7.5	3.5-6, >7.5	<3.5	Reduces optimum plant growth
Effective cation exchange capacity (c mol/kg)	>15	3-15	<3	Unable to hold plant nutrients

(Source: Environmental Guidelines, Department of Environment & Conservation, Sydney, October 2004).

5.2 Effect of Effluent Irrigation on Soil properties

5.2.1 Using Secondary Data

In order to study the effect of using the effluent for irrigation in the paper recycling units on soil quality, secondary data furnished by TNPCB for 27 locations for the year 2006 have been analysed (Tables 5.2, 5.3, 5.4 & 5.5). It is reported by TNPCB that the above soil samples have been collected in the irrigation areas of the paper recycling units located at Erode District. The various soil properties analyzed include parameters such as pH, EC, N, P, K, Fe, Mn, copper, boron and SAR.

The pH of the 27 soil samples was found to be in the range of 6.5-8.6 indicating that the samples were neutral to moderately alkaline in nature and thus posing slight to moderate limitation for plant growth (as per Table 5.1) The EC_e for 27 samples ranged from 0.20 to 4.0. Out of 27 samples, 15 samples had EC_e values of 2 and above. (Value of 2 is limit beyond which excess salt may restrict plant growth).

5.2.2 Using Primary Data

Soil samples were collected from the irrigation areas of 2 industries by CES on 11.4.09 in Dindigul District. Also a control sample was collected in Dindigul District. The samples have been analysed as per Standard Method and the results are presented in Table 5.6. The pH of all the samples was found to be in the range of 7.26-7.55, which means that the samples were neutral to slightly alkaline and hence there is nil or slight limitation to plant growth. The EC_e (Electrical Conductivity of a water saturated soil paste) values were in the range 0.29 to 0.41 dS/m and thus nil or slight effects on plants. The organic carbon content (1.08-1.74%) in the effluent irrigated area samples were found to be higher than the control samples (0.45%). This might be due to the accumulation of suspended and dissolved organics present in the effluent. The boron was found to be BDL in all the samples. The ESP was found to be in the range of 16-27. The ESP value of greater than 10 possess severe limitation to plant growth since it results in structural degradation and water logging in the soil.

5.3 Review of Select Studies conducted by Others

Tamil Nadu Agricultural University (TNAU) conducted a study on evaluation of long-term effect on utilisation of M/s.Tamil Nadu Newsprint and Papers Limited (TNPL) effluent for irrigation. Continuous monitoring of soil and ground water quality in the irrigation area of TNPL was carried out. The pH (7.34-8.71) and ESP (26-49) of soil within ayacut area was higher than the control samples. Also high organic content and nitrogen were found in soils due to continuous irrigation. Similarly continuous effluent irrigation had increased pH (8.02-9.12) and EC (2.12-5.19 dSm^{-1}) of ground water samples compared to control samples. The other ground

water quality parameters viz. chloride, sulphate, salinity, SAR and % sodium were also increased due to continuous effluent irrigation compared to control samples (Ref: Elayarajan et al, Madras Agric. J.92 (7-9): 469-478, July-September 2005).

A study was conducted by Kannan and Oblisami, (1990) on influence of irrigation with Pulp and Paper Mill Effluent on soil chemical and microbiological properties. In the study, it was reported that irrigation of sugarcane crops with combined pulp and paper mill effluent increased the soil pH, organic carbon, N, P and K. Also due to long-term application of effluent, exchangeable sodium increased by 4.5 fold compared to control sample. The combined effluent irrigation increased soil populations of bacteria, actinomycetes, fungi, rhizobia and yeasts. Microbial populations were directly proportional to soil organic carbon and to available nutrients in the soil (Ref: Kannan and G.Oblisami, Bio Fertil Soils (1990) 10:197-201).

The effect of irrigation with paper mill effluent on nutrient status of soil was studied by Santhosh Kumar Singh (2007) at Lalkuan, Nainital District, India. It is reported that use of paper mill effluent for irrigation had a substantial effect on soil properties (Table 5.7). The EC_e organic carbon, K, exchangeable cations (Ca^{2+}, Mg^{2+}) and anions (HCO_3^-, Cl^-) were found to be significantly higher as compared to control. The high increase in salt concentration was of particular concern as it may lead to salinity hazard in long term use (Ref: Santhosh Kumar Singh, International Journal of Soil Science 2 (1): 74-77, 2007).

Table 5.2 Soil Quality in the Irrigated Area of Paper Recycling Units, Erode, 7.8.06 (Source: TNPCB)

Sl.No.	Parameter	Selvaraj Paruthampalayam	Chellamal parutham	Uchappa kaunder Parutham	Rangasamy Boglakarai	Jambana Kaunder Bogana	Kariappa kauder mukkanathappalli
		Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
1.	Calcium carbonate	Medium	High	Absent	Absent	Medium	Medium
2.	EC_e, dSm^{-1}	0.7	0.4	0.3	0.6	0.7	0.6
3.	pH	8	8.2	8.4	8.6	8.0	8.2
4.	Nitrogen, kg/acre	78	87	101	81	80	73
5.	Phosphorous, kg/acre	5.6	5.8	5.2	6.0	5.4	5.2
6.	Potassium ,kg/acre	100	160	83	380	90	110
7.	Fe, ppm	5.62	4.81	5.18	4.54	3.95	5.23
8.	Manganese, ppm	3.18	2.52	1.84	2.18	2.34	1.95
9.	Zinc, ppm	1.24	1.38	1.17	1.41	1.01	7.34
10.	Copper, ppm	1.18	0.98	1.21	1.15	0.82	1.10
11.	Boron, ppm	-	-	-	-	-	-

Table 5.3 Soil Quality in the Irrigated Area of Paper Recycling Units, 24.8.06 (Source: TNPCB)

Sl.No.	Parameters	Rangasamy Puduppirkadaru	Samiappan kothamangalam	Venkatasalanta Pudup	Madaraya kaunder pudup	Venkatrama Asari pasuvanapalayam	R.Maniappan pudup
		Sample 7	Sample 8	Sample 9	Sample 10	Sample 11	Sample 12
1.	Calcium carbonate	Absent	Medium	Absent	Absent	Absent	Absent
2.	EC_e, dsm^{-1}	0.4	0.3	0.4	0.3	0.2	0.2
3.	pH	7.8	8.5	8.4	8.2	8.6	8.6
4.	Nitrogen, kg/acre	70	67	76	81	69	73
5.	Phosphorous, kg/acre	6.0	5.0	4.8	7.0	5.4	6.4
6.	Potassium, kg/acre	40	33	35	58	38	65
7.	Fe, ppm	5.76	3.92	4.16	5.12	4.98	5.44
8.	Manganese, ppm	2.14	1.96	2.42	3.04	2.68	2.18
9.	Zinc, ppm	1.42	0.96	1.14	1.12	1.01	0.98
10.	Copper, ppm	0.98	0.92	0.84	0.94	1.01	0.88
11.	Boron, ppm	-	-	-	-	-	-

Table 5.4 Soil Quality in the Irrigated Area of Paper Recycling Units, 21.8.2006 (Source: TNPCB)

Sl.No.	Parameter	SPW1	SPW2	SPW3	SPW4	SPW5	SPW6	SPW7	SPW8	SPW9
1.	pH	7	6.9	7.0	6.9	7.1	7.2	7.2	6.5	7.3
2.	EC_e, dsm^{-1}	3.2	4.0	3.6	3.4	3.2	2.9	2.8	3.1	1.9
3.	Bicarbonate, meq/L	4.8	8.0	8.2	3.2	3.0	6.6	5.8	9.6	4.2
4.	Chloride, meq/L	13.5	20.8	20.7	15.6	15.1	11.3	11.0	17.1	3.2
5.	Sulphate, meq/L	12.5	11.55	6.25	15.0	14.35	10.65	10.65	3.15	10.95
6.	Calcium, meq/L	14.5	16.5	15.6	21.1	14.8	18.6	14.2	17.6	9.2
7.	Magnesium, meq/L	10.6	14.5	11.1	8.8	12.3	6.2	10.7	10.6	5.7
8.	Sodium, meq/L	6.25	8.75	8.75	3.75	3.75	3.75	2.5	2.5	3.75
9.	Potassium, meq/L	0.31	0.28	0.26	0.23	0.51	0.23	0.2.	0.15	0.13
10.	SAR	1.8	2.2	2.4	0.97	1.02	1.38	0.71	0.7	1.37
11.	Major salt Character	$CaCl_2$	$CaCl_2$	$CaCl_2$	$CaCl_2$	$CaCl_2$	$CaCl_2$	$CaCl_2$	$CaCl_2$	$CaCl_2$

Table 5.5 Soil Quality in the Irrigated Area of Paper Recycling Units, Erode, 25.8.06 (Source: TNPCB)

Sl.No.	Parameter	SPW10	SPW11	SPW12	SPW13	SPW14	SPW15
1.	pH	7.0	7.2	6.9	7.4	7.1	7.0
2.	EC_e, dsm^{-1}	3.7	3.6	3.9	3.5	2.8	2.2
3.	Bicarbonate, meq/L	4.6	4.9	5.6	6.5	5.4	4.8
4.	Chloride, meq/L	18.5	17.8	19.4	18.8	16.1	12.9
5.	Sulphate, meq/L	13.15	13.15	13.75	9.7	6.25	3.0
6.	Calcium, meq/L	16.3	15.8	20.4	17.6	12.1	8.9
7.	Magnesium, meq/L	16.8	11.2	14.6	10.8	9.3	9.2
8.	Sodium, meq/L	3.75	8.75	3.75	6.25	6.25	3.75
9.	Potassium, meq/L	0.15	0.20	0.23	0.26	0.26	0.15
10.	SAR	0.93	2.43	0.89	1.64	1.95	1.25
11.	Major salt Character	$MgCl_2$ & $CaCl_2$	$CaCl_2$	$CaCl_2$	$CaCl_2$	$CaCl_2$	$CaCl_2$

Table 5.6 Soil Quality in the Irrigated Area of Paper Recycling Units, Palani, April 2009 (Primary Data, CES)

Sl.No.	Parameters	Industry A		Industry B		Control Sample
		Sample 1	Sample 2	Sample 1	Sample 2	
1.	pH	7.28	7.40	7.55	7.43	7.26
2.	EC_e, dS/m	0.41	0.29	0.30	0.36	0.46
3.	Calcium as Ca^{2+},mg/kg	93	184	122	286	202
4.	Magnesium as Mg^{2+}, mg/kg	4.8	3.8	3.2	1.9	9.7
5.	Boron, mg/kg	BDL	BDL	BDL	BDL	BDL
6.	Sodium, mg/kg	40	50	60	60	90
7.	Potassium, mg/kg	40	50	30	30	40
8.	Available phosphorous, mg/kg	187	230	76	70	294
9.	Organic carbon (%)	1.74	1.14	1.08	1.71	0.45
10.	Nitrogen, mg/kg	360	390	338	445	131
11.	ESP (%)	23	16	27	15	25

Note: Boron detection limit : 0.5 mg/kg

Table 5.7 Effect of Pulp and Paper Mill Effluent on Soil Quality

Parameters	Irrigated Area Sample	Control Sample
pH	7.79	7.60
ECe(dS/m)	0.49	0.28
% OC	1.32	0.74
N (kg/ha)	206	165
P (kg/ha)	18	14
K (kg/ha)	171	116
Ca (meq./100 g)	13.5	8.2
Mg (meq./100 g)	4.4	2.11
Cl^- (meq./100 g)	0.36	0.22
HCO_3^- (meq./100 g)	0.54	0.28

CHAPTER 6

Recycling of Treated Effluent

6.1 The Need for Recycling

1. Effluent standards prescribed for industrial effluents for discharge into environment have their own strength and weakness. When the environmental resources were abundant, volume of the effluents was small and characteristics of the effluent was non-toxic, the limiting levels of pollutants in the effluent could have prevented adverse impact on the environment. But, today, with scarce resources, complex industrial effluents discharged in huge volumes, time has come to move away from meeting the effluent standards. A right step in this direction is the recycling of water in the industry.

2. Industries use enormous amount of natural resources (like water) in the production process. Due to ever increasing water demand and diminishing resources availability, the stress on the water resources (like river and ground water) is on the increase. The recycling of treated effluent will ensure that water is conserved.

3. It is time to change the course-rather than releasing the chemicals and mitigating the damages (end of pipe), we could prevent problems at source by preventing the release of chemicals into the environment in the first place. This is in line with the precautionary principle stated in our National Environmental Policy, 2006.

4. Today, there is a greater demand for sustainable industrial operations. Industries are expected to serve wider to meet the aspiration of the society. In addition, international markets emphasis the need for environmental compliance on par with the product quality.

6.2 Status of Recycling in the study units

It is found that 26-78% of the total water demand is met from the recycling process.

6.3 Fresh Water Usage in the process

As already stated, the fresh water consumption in the industry varies from 174 m^3/d to 3685 m^3/d. The unit fresh water consumption (fresh water consumed per tonne of product) varies from 6 to 81 m^3/t.

The CPCB has taken steps to minimize the water consumption in the pulp and paper industries ingeneral. For this purpose, in 2006, CPCB requested that National Productivity Council (NPC), New Delhi, to prepare the guidelines for the water conservation in the pulp and paper industries. The NPC has submitted its recommendations to the CPCB. The recommendations of NPC for the waste paper based industries along with the data related to the study units are presented in Table 6.1 (Source: Development of Guidelines for Water Conservation in Pulp and Paper Sector, NPC, 2006).

Table 6.1 NPC Recommendations and Study Units Data

Sl. No.	Category Description	Proposed Water Consumption (m^3/tonne of product)			Fresh water consumption in Study Units (m^3/tonne)	
		Bench Marks	Best Achievable	Relaxed	Lowest	Highest
1.	All Waste paper based pulp and paper mills manufacturing high grade cultural paper and / or newsprint with 'Deinking'	19	41	49	15	74
2.	All Waste paper based pulp and paper mills manufacturing high grade cultural paper without deinking	9	13	15	6	81

From the Table 6.1, it is inferred that the present fresh water usage is more than Bench Mark standard set by NPC. At international level, fresh water consumption is at 5-10 m^3/t of product.

6.4 Quality of Water for the Process

As already stated, the industries use mostly river water and in some cases ground water from bore wells. No quality check appears to be done and no treatment appears to be imparted to the water. Water is as such drawn and used in the process. It was also ascertained from the industries that normal river water quality would meet the requirements. Even the guidelines for water quality recommended by different organizations (Annexure A) also support this conclusion.

6.5 Non-Paper Wastes

It is ascertained that the waste paper bales (especially those imported) contain non-paper wastes in significant amounts. This needs to be segregated by the user and managed appropriately. Otherwise, they will interfere in the production process and in the effluent treatment.

6.6 Answers to TNPCB's Questions

1. Whether the ZLD arrangement for discharging treated trade effluent in the paper industry is the most technically feasible clean arrangement (or) whether 100% reuse of backwater is not technically feasible?

   100% reuse of wastewater is technically feasible, in the light of advances in the wastewater reclamation technology.

2. Whether ETP discharges, after appropriate treatment through activated sludge process will be injurious to ground water and cultivation of crops?

   Yes. The data available indicates that the high TDS treated water from the existing ETPs may have adverse impacts on groundwater and crops. (Please see Chapter 3)

3. Whether continued discharge of treated effluent in waste paper industry can result in ground water and soil pollution over a period of time?

Yes. Please see chapters 4 and 5.

6.7 Suggested Action Plan for the future

Considering the points presented in sections 6.1 to 6.5 of this Chapter, the following Plan of Action is suggested for the management of the effluents from the waste paper based industries manufacturing paper and newsprints:

1.0 The industries should take all possible measures (like process / equipment modification, improved internal recycling practices, good house keeping) to conserve the fresh water requirement and work towards the Bench Mark target set by National Productivity Council.

2.0 Once the wastewater generated becomes less in volume, then the treatment becomes economical. Industry may choose appropriate treatment technology to treat atleast 75% of the effluent as a first step and recycle the same in the process.

3.0 The remaining 25% of the effluent can be treated to meet the land discharge standards and discharged on land for irrigation.

4.0 Activities 1.0 to 3.0 stated above may be completed within a maximum period of 5 years.

5.0 The industry should monitor the impact of the discharge on ground water and soil in the vicinity of the industry by having monitoring wells in consultation with TNPCB and use the data for remedial measures, if necessary.

6.0 The TNPCB may undertake to review the situation periodically and especially after 5 years, to make further decisions, as necessary.

Director-CES

ANNEXURE – A

Characteristics of Water for Paper Making

The principal qualities of water that determine the suitability for pulp and paper mill purposes are as follows:

1) Colour
2) Suspended matter
3) Presence of Manganese
4) Presence of Iron
5) Hardness
6) An excess amount of dissolved mineral water
7) Silica

Colour

Water having little or no colour is essential for manufacture of paper. The colour of water is generally due to dissolved organic matter derived from vegetation or to iron salts.

Suspended Matter

Suspended matter is troublesome in the manufacture of paper or pulp, because it becomes entangled in the fibres, thus causing spots and other imperfections in the finished product. Coarse particles of suspended matter (eg. grit) may cause damage to equipment and result in pinholes in the paper.

Iron

The presence of iron in water is most objectionable, since cellulose has the property of adsorbing iron and other metals from dilute solutions. In the pulp and paper making process, cellulose is constantly in contact with the water and iron if present may be adsorbed.

Manganese

The presence of manganese in the water of paper mill may be exceedingly troublesome. Manganese is more frequently found in ground waters, although it has been found in many surface waters. Manganese causes effects similar to these of iron as to staining and discolouration. They are more troublesome because it oxidises and results in formation of black hydrated oxide. Manganese is objectionable in bleaching operations since, if manganese bearing water comes cover in contact with stock containing bleach, the chlorine will oxidize the manganese to permanganates, which imparts a reddish colour to the fibres.

Iron Bacteria

They have the property of precipitating iron and also manganese. They often develop in pipelines, especially dead ends where accumulations form and if accumulations break away they will cause spots in the product.

Permissible amounts of Iron & Manganese

The amount of iron permissible in water used for paper making depends on the product to be manufactured. For high grade paper where colour is a primary consideration, water should not contain more than 0.1 ppm of iron. In the TAPPI specification E 600, S-48, the amount specified as permissible for unbleached papers need not be lower than 0.5 ppm. For bleached papers (eg. Writing and other high grade papers), the maximum amount of manganese should not exceed 0.1 ppm.

Removal of Iron & Manganese

The conventional methods of coagulation and filtration will remove ferric iron. Aeration will remove ferrous iron. The removal of manganese is usually accomplished concurrently with removal of iron. Iron and Manganese may also be removed along with hardness in zeolite softeners by use of special zeolites.

Disinfection of Fresh Water and White Water

All surface waters and some ground waters contain bacteria and fungi in varying numbers. These microorganisms develop and accumulate in the stock systems of pulp and paper

mills and cause what is known as paper-mill slime. Some microorganisms can utilize cellulose as a source of carbon and they build up a gelatinous slime on the fibres. Slime is particularly objectionable in the paper mill and may cause slime spots and pinholes or even breaks in the paper and it may result in poor formation of sheet. This slime also collects on screens, save all, wires and other equipment and makes frequent cleaning up periods with resulting loss of production.

Effects of hardness on Sizing

Hard waters are troublesome when sizing with rosin, the mineral salts reacts with size forming insoluble calcium and magnesium rosonates, which have no sizing action. The salts present in water affect colloidal condition of the size, tending to make the rosin gather into large particles, thereby reducing its covering power. The difficulty of sizing with hard waters can be overcome to some extent by increasing the amount of alum.

Effects of hardness on Scale formation

Hard water are also objectionable because of the tendency to form scale (wherever they are constantly in contact with metal parts). When the machine wires become coated with scale, frequent scouring with sulphuric acid is necessary, which greatly shortens life of the wires.

Soft Water not essential

While soft waters are more desirable, they are not absolutely essential in paper making processes. Excellent papers are made with hard waters that meets other requirements of freedom from iron, colour and suspended matter. It is reported that book paper of high quality is produced with very hard water (700 ppm).

Water Softening

The softening of entire water supply is not economically feasible. Water used in connection with rosin sizing and for boiler purposes should be softened. On the other hand, waters used for showers do not require softening.

Effects of Corrosion

Iron rust may produce discoloration of the product and cause black specks or spots in the paper. Corrosion reduces life of machine wires, screens, pulps and practically any equipment in the mill system.

Showers

In connection with the reuse of white waters on showers, pipes with openings larger than those ordinarily used with fresh water are advisable.

Foam

Foam difficulties may be accentuated by the use of white water.

Water Quality Guideline for Paper Industry

The water used in most of pulp and paper making processes are in direct contact with the raw material. Therefore the quality of water used in the process tremendously affects quality of water produced. The pulp adsorbs dissolved solids and metal irons in the water when the water is being filtered on the wire section. The SS will be captured by pulp. When the moisture in the pulp is evaporated in the drying section, the SS remained in the pulp will be affecting quality of end product. The sizing agent, dye, fluorescent and bleaching agent will be reacted with SS and thus product quality will be affected. If the quality of water is not good, it will cause corrosion of paper making equipment, scales buildup inside pipes, etc. This will directly or indirectly affect production capacity.

In 1970, Japanese Government did a survey on quality of water used for different processes (eg. Cooling water, clean shower water, etc.) and based on American TAPPI standard, proposed the water quality guideline for each different grades of paper products (Table A-1). Kawano et.al further studied water quality requirement for different processes and proposed water quality guideline for each different unit (Table A-2).

Table A-1 Water Quality Standard for Fine Paper

Turbidity (SiO_2), ppm	10
Color (Pt-Co)	5
Total hardness ($CaCO_3$), ppm	100
Calcium hardness ($CaCO_3$), ppm	50
Fe, ppm	0.1
Mn, ppm	0.05
Residual Chlorine , ppm	2
Dissolved silica (SiO_2), ppm	2
TDS, ppm	200
Free carbonate (CO_2) , (ppm)	10

Table A-2 Water Quality Standard for Paper Making Process (Shower Water)

Turbidity (NTU)	5
pH	7.5
Alkalinity ($CaCO_3$) (mg/L)	80
Hardness ($CaCO_3$) (mg/L)	30
Evaporated residual(mg/L)	100
Chlorine ion (Cl^-)(mg/L)	10
Fe(mg/L)	0.05
Mn(mg/L)	0.02