Constraints and Prospects of Closing Bleached Kraft Pulp Mills

Mittal S.K. & Maheshwari Subhash

Eco-efficient thinking always recommend to utilize our resources in most effective and optimum manner. Pulp and paper industry which is highly water intensive industry always comes under scrutiny by various concerned agencies which have similar thinking. It has become very important to review time to time the performance of existing mills with respect to overall environmental impacts and possibilities to incorporate systems and technologies being developed to conserve the water by its optimum use.

This paper briefly discusses the modern approaches and various systems being developed to close the bleached kraft pulp mills in terms of liquid discharge. Various constraints and propsects to adopt these approaches also discussed briefly. PHOENIX, a market pulp mill, has taken a lead to respond quite positively on these eco-efficient approaches to use water in optimum way. The experience gained at PHOENIX in this regard has been briefly described in this paper.

A careful review of overall systems, approaches and experience gained at PHOENIX clearly indicate that there are good possibilities to significantly reduce the water consumption. However, constant and careful followup in all the related areas would be required to get the optimum benefits.

The efficient water use and conservation of water has ecological merits and this view has influenced the people and increased the awareness on environmental issues related to water use. These issues affected the pulp and paper industry by a factor i.e. environmental assessment process. In most part of the world it has become compulsory to undergo such an extensive study for identification of impacts on environment and their metigation measures for existing mills, expansions and in new capacity build ups. As industry is quite water intensive one and water consumption remains always under critical review for improvements in the systems.

During the process of reduction of water, the concept of complete closure of mills was developed by Rapson (1) and was tried for short period on mill scale as well. The main features of the concept were:

1. Use of contaminated condensates.
2. Closed screening room.
3. Spill collection system.
4. Perfect counter current washing
5. Salt control system.

The trials on mill scale were discontinued due to increased bleaching chemicals consumption, corrosion problems, and energy related issues. However, this experience has given a way towards the **complete closure of mills.** The closure of kraft pulp mills has been focussed mainly on the bleach plant as its effluent is considered most polluting and difficult to handle. The effluent from other sections are segregated, recovered and reused efficiently with or without some treatments. It may be mentioned here that the conventional effluent treatment systems including activated sludge process are not capable to reduce significantly COD (lignin based), dissolved solids, colour and inorganic compounds. With the growing industrialization the water bodies are not capable in accomodating even the small pollution loads of any kind coming even with fully treated waste water. Due to these reasons

Phoenix Pulp & Paper Public Co., Ltd.,
P.O. Box 102,
Khon Kaen-40000 Thailand

efforts are constantly in progress to reach to complete closure of mills. This paper deals a few approaches and PHOENIX experience in this regard.

APPROACH FOR CLOSURE

The various steps are taken by the mills time to time to minimize the water use by improved house keeping, segregation of clean and waste water, improved process conditions and reuse of waste water in the process.

These efforts have made tremendous impacts world over on water consumptions in pulp and paper industry. It has been reported that with various such efforts water use from the industry has been decreasing steadly over last five decades and presently standard new mills are designed on an average below 30-35 M^3/ADT pulp basis.

The main reason of limitation of complete reuse of water in the process and reaching towards the **closed mill concept** depends on the concentration of chemical constituents in the waste water. With the view to reduce chemical constituents of high environmental impacts and at the same time to have more opportunity to recycle the water following steps are developed and come into practice for kraft pulp mills operations.

Extended Delignification

With a view to decrease volume and concentration of effluent discharged from the kraft bleach plant extended delignification has been successfully incorporated. Various cooking technologies including Super Batch, Enerbatch, RHD, RDH-Enerbatch, Modified Continuous Cooking (MCC), Iso Thermal Cooking (ITC) etc. are developed and many of them are successfully running. With incorporation of these processes a very low kappa number pulp is obtained, without any significant adverse impact on pulp properties, which results in lower bleaching chemical requirement and subsequently low pollution loads and chemical concentrations to effluent.

Oxygen Delignification

Use of oxygen for further delignification is another step to reduce the pulp kappa number and ultimately reduce bleaching chemicals. The oxygen delignification is kept in close loop with brown stock washing. In this stage kappa number can be reduced 35-45% which results in similar reduction in BOD, COD, colour and other inorganic loadings in bleach plant effluent. It is reported that now more than 50% world's bleached kraft pulp production is using this stage. However, incorporation of this stage in the existing mills requires carefully overall material balance of the mill. Efforts are also on to establish second stage of oxygen delignification to fit in with the various techno-economic constraints of the mills.

Bleaching Sequence

The chlorinated organic compounds became matter of concern which resulted in limitation of use of elemental chlorine. It also restricts closure of mills as chloride ions are most corrosive. This fact brought the concept of Elemental Chlorine Free (ECF) bleaching sequence with 100% substitution of Cl_2 by ClO_2. However, use of chlorine dioxide in bleaching also results in some chloride ions and some toxic chemicals but in a very low concentration. This developed further the idea of totally chlorine free (TCF) bleaching sequence and subsequently total closure.

Use of oxygen based chemicals including Ozone, Oxygen, Peroxide, Peracids etc are incorporated in TCF bleaching sequence. But it is experienced that TCF bleaching sequences based on oxygen related chemicals increases the cost for raw material, chemicals, energy and equipment. At the same time toxicity of effluent of ECF bleaching sequence with new cooking system and TCF sequence are also found more or less comparable. Efforts are now on to come to a via media where oxygen based chemicals and ClO_2 are used together and which suit to existing and new mills to get overall improved environmental situation alongwith other advantages of ClO_2 use.

Process, Equipment and System Selection

The developmental efforts are also on to further improve the process, equipment and systems which will not only use low volumes of water but also require low energy and generate low

pollution loads from the process which will make the closure of process easier.

CLOSURE OF BLEACH PLANT

Apart from various efforts made, as discussed above towards closure of kraft pulp mills further efforts are on to integrate the bleaching filtrates in the process to reach to **zero level** of effluent discharge from the mills. A few systems with this approach are described briefly below:

Bleach Filtrate Recovery (BFR) System

This system is developed by Champion International Corporation to eliminate chemicals produced in elemental chlorine free (ECF) bleach plant (2&3). In the process filtrates from Do and extraction stage are taken to kraft recovery cycle. The organic contents of the filtrate are burnt and inorganic contents are removed separately. Chlorides from bleach plant and potassium coming with wood are purged from Chloride Removal Process (CRP) which operates on the basis of greater solubility of sodium and potassium chloride relative to sodium sulfate. ESP dust which is enriched in chlorides and potassium is dissolved and recrystallized to produce solid sodium sulfate which is sent to recovery cycle and concentrated aqueous chloride and potassium waste streams come out as purge from CRP system. The mineral impurities from wood such as calcium, magnesium and manganese are purged from **"Metal Removal Process"** to avoid any build up in system. It has been reported that this system is in operation at Champion mill for demonstration. Its simple flow diagram is given in Fig.-1.

Zero Liquid Effluent Process

Zerotech Technologies Inc. developed and demonstrated successfully Zero liquid effluent process at a BCTMP market pulp mill in Canada(4). In this system (Fig.-2) all the waste water collected and after primary treatment sent to Mechanical Vapour Recompression (MVR) evaporator via fiber filter. The waste water is concentrated from 2% solids to 35% dry solids. The distillate (or condensate) from MVR evaporations is segregated into fractions and used directly or sent for cleaning through steam stripper to remove volatile organic compounds.

The concentrate from MVR evaporator is

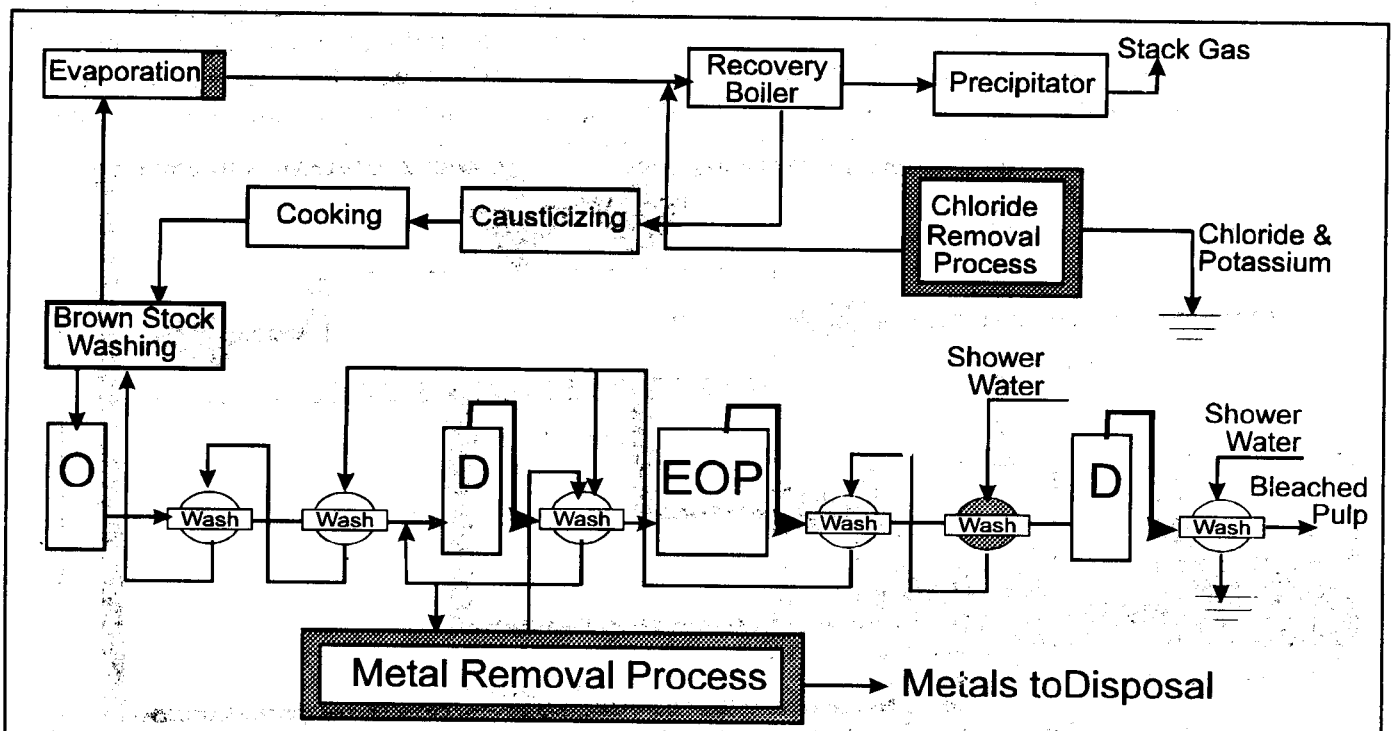

Fig. 1: Bleach Filtrate Recovery (BFR) Process

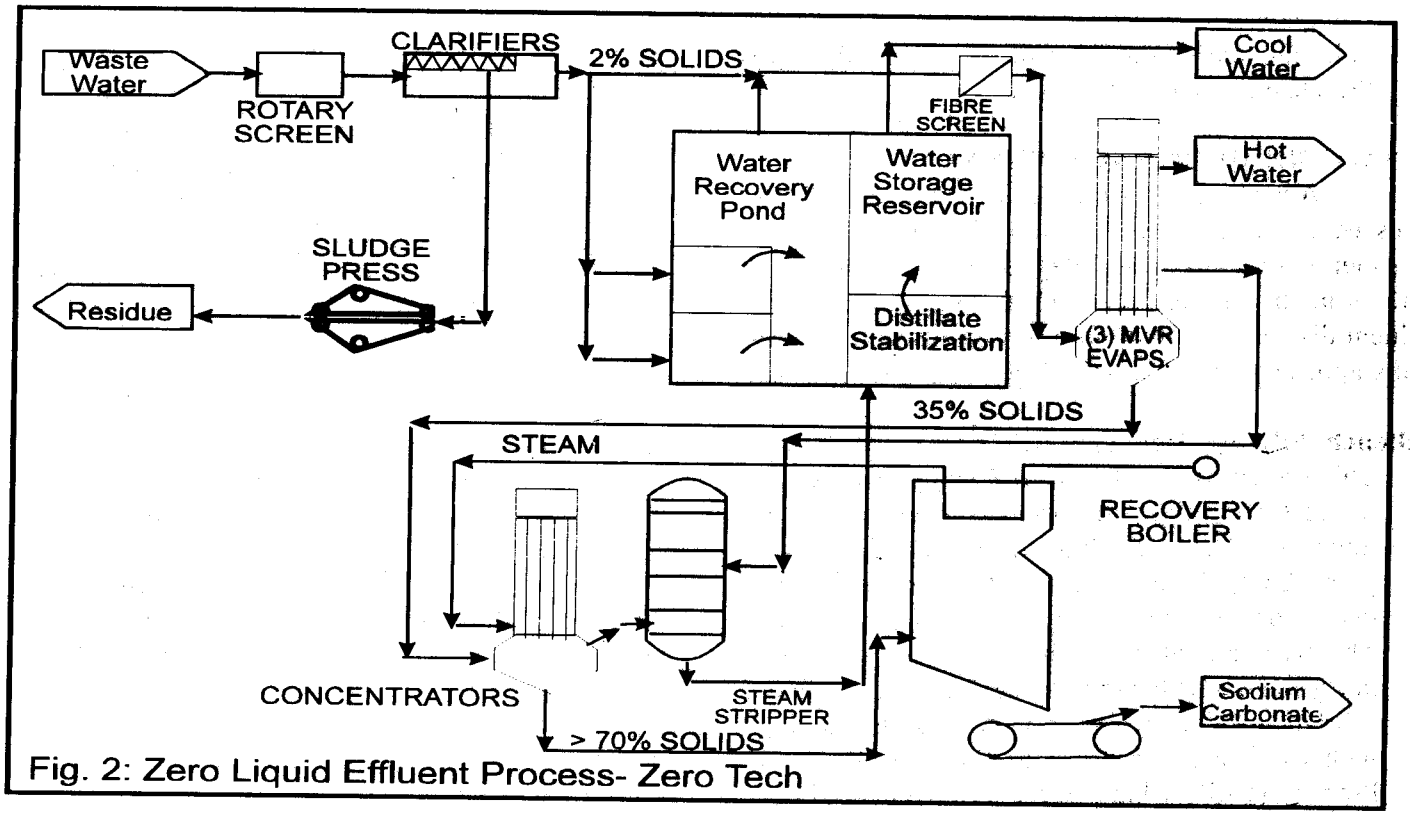

Fig. 2: Zero Liquid Effluent Process- Zero Tech

further concentrated to 70-75% dry solids in two steam driven concentrator and incinerated in chemical recovery boiler. The smelt from furnace is cooled, solidified and deposited in a bunker. This system is in operation successfully for last four years. Further investigations are in progress to treat TCF and ECF bleach plant filtrate through this system(5).

Zedivap Zero Discharge

Ahlstrom Corporation has come out with a low cost, low energy zero discharge evaporators(6). In this system (Fig.-3) effluent is concentrated in 8 to 15 consecutive stages at temperatures from 30 to 80°C under reduced pressures. All type of waste heats from the system i.e. warm water, flue gases, etc are used in this system. The

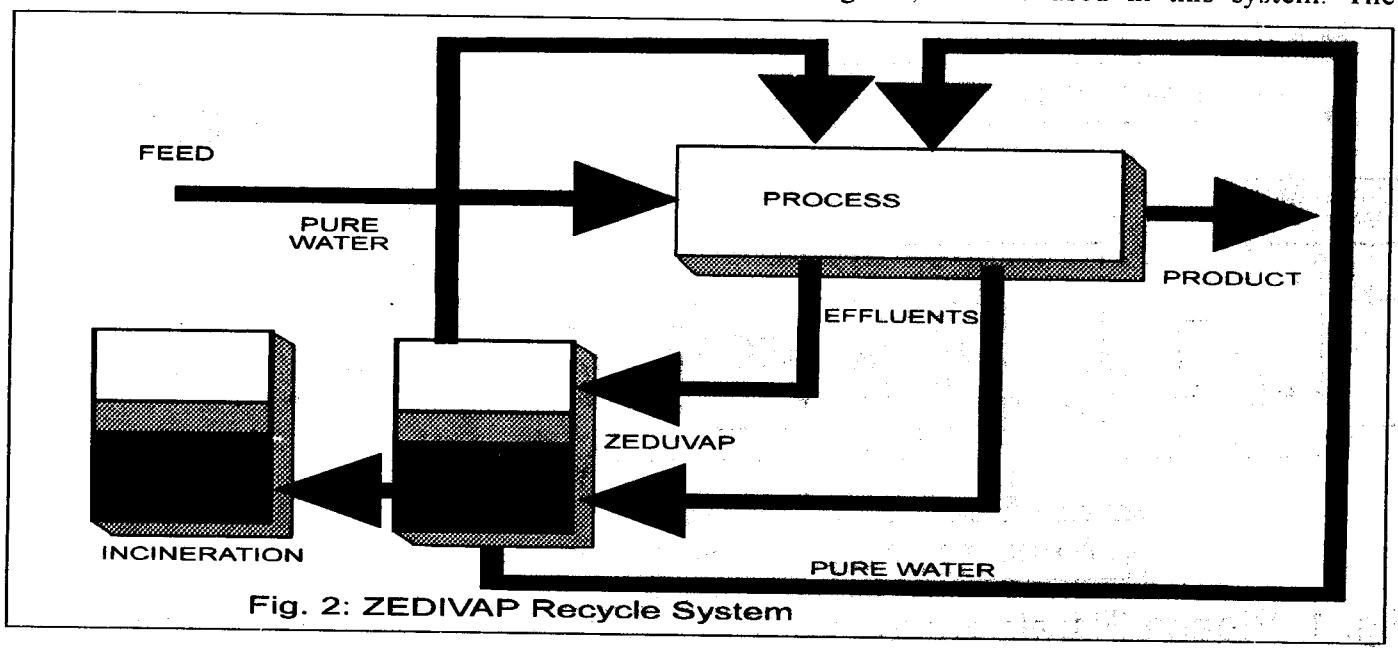

Fig. 2: ZEDIVAP Recycle System

condensates are collected and used back in the process either as such or after passing through stripper to remove volatile compounds. The concentrate from evaporation is taken to final concentrator and subsequently incinerated.

Apart from these systems other efforts are also in progress in this regard to develop system which can help for closure of mills.

ISSUES REQUIRE ATTENTION

Various efforts made by pulp and paper mills have very positively affected not only the reduction of volume of waste water but total chemical & pollution loading also. This has given a way to go to the level of zero discharge. However, the following few aspects require special attention while incorporation such schemes for closing the mills.

Deposits,

The incorporation of various schemes for closing the mills further aggravate the problems of deposits i.e. inorganic and organic scales through out the system. The mills normally try at some locations special additives and chemicals to avoid deposits and at some locations periodic mechanical cleaning. However, this aspect has to be critically reviewed time to time with the closing of the mills.

Non Process Elements.

A large quantity of inorganic compounds which come mainly from wood get accumulated in the system as these have little opportunity to be purged out in closed cycle. Normally the heavy metal ions such as manganese, copper, iron etc which are present in wood get concentrated and adversely affect the various process operations particularly bleaching chemical response, pulp degradation, recovery operations etc.

Chloride Concentration

Closing the bleach plant has distinct affect particularly for chlorine compound based bleaching sequence including ECF and it requires special attention. The chloride ions build up in the system causes severe corrosions, deposits etc.

Material Balance

The complete closure of mill has direct impact on the material balance specially of sodium and sulfur and capacities of individual sections mainly of chemical recovery. Hence, proper inorganic & organic compounds, water and electrical & steam energy balances etc. have to be critically reviewed before going ahead with closure. Here it is worth while to mention that the increase closure many a times cause more electrical energy consumption and the aspect also require special attention.

ETP Operations

It is very important to note that during the process of reduction of water consumption the concentration levels of organic and inorganic contents in effluent increase significantly which many a times result in adverse affect on effluent treatment plant operations. The reduced water consumptions also increases the effluent temperature and requires cooling to have good performance of ETP. At the same time if the regulations are on concentration basis effluent treatment requires special attention to meet the regulations.

PHOENIX APPROACH

PHOENIX from its inception adopted **best available technologies and systems** and has been putting its best efforts to reduce the water consumption. The mill has two lines and producing 100,000 TPA each market pulps from kenaf, bamboo and eucalyptus a raw materials. Its line number 1 started production in 1982 and line-2 in 1994. The details of the processes are reported earlier in IPPTA Journal(7). The approaches followed at PHOENIX to reduce water consumption are briefly described below:

Good House Keeping

This is an important area which can significantly cut down the water consumption. Special care is taken at the mill to have very good water distribution system with proper maintenance. The efficient use and minimum wastage have given good results at PHOENIX. Due care has been taken to plan water and effluent drainage system in the mill.

Inprocess Reuse of Water

The reduction of water through this method requires special attention for planning of water use in both the lines. Time to time various schemes have been implemented to reduce water consumption particularly line-1. The waste water discharged from individual section is characterised periodically and possibility is explored wherever it can be suitably used. It may be noted that higher recirculation results in higher consumption of energy, additives and chemicals, higher scaling and corrosion and some time imbalance in waste ,water characteristics as mentioned above. Hence, due care is being taken while implementation of water reduction schemes so that these should not affect process, equipment, waste water and product quality.

Efficient Process, Equipment and Systems

The following changes have been incorporated in line number 1 to reduce the water consumption, pollution load and chemical loads in the effluent.

- o Incorporation of Oxygen Delignification stage.
- o Installation of displacement presses in post oxygen delignification washing
- o Change of bleaching sequence.
  CEHD ----CEoHD ---CEoDD---C/DEoDD
  (Initial) (Present)
- o Algas microfilter to efficiently reuse Sheeting Machine back water.

In line number 2 the process equipment and systems selections were done with a view to have minimum water consumption with low pollution loads. The selection of material of construction for pumps, pipe lines etc was also accordingly made. The main features of this line with particular reference to low water consumption are as given below.

- o Extended Delignification cooking system.
- o Efficient screening and washing systems with displacement press.
- o Oxygen delignification stage with post washing on displacement presses.
- o ECF bleaching with Do Eo D_1 D_2 stages and with intermediate washing.
- o Efficient post bleaching screening system.
- o Closed sheeting machine back water system.
- o Condensate recovery system
- o Cooling towers.

The above efforts combiningly for line 1 &2 resulted in reduction of water from 126 M^3 to 35 M^3 with in 5 years of time is given below.

Effluent Flow at PHOENIX

Year (Average)	Effluent flow f(m^3/tonne pulp)
1991	126
1992	106
1993	90
1994	55
1995	45
1996(since June,96)	35

PHOENIX is very carefully following the recent developments regarding total closure of mills and reviewing possibility of incorporation of techno-economical and environmentally sound system at mills.

PROJECT GREEN

The use of waste water from pulp and paper mill always remained an interesting subject of study and implementation in tropical countries like China, India, Indonesia, Thailand etc. particularly where availability of irrigation water is limited. A few reports are also available based on successful use of waste water for irrigation of different crops (8-9). Recently under UNEP/NIEM activities in Asia & Pacific region including Thailand conducted detailed investigation on use of pulp and paper mill waste water for irrigation(10). These studies generated various data in this regard and confirmed that under given conditions pulp and paper mill waste water

can be used for irrigation of different crops without any adverse effect on water, soil and crop characteristics.

In view of increasing social and industrial activities in the north eastern region of Thailand where PHOENIX is situated particularly by the side of Nam Pong river from where mill draws water and discharges treated effluent and also due to fluctuations in rainfall put the limitation of river to take additional pollution load without adversely affecting the river water quality. The concerned authorities after due consideration advised PHOENIX to limit discharging treated effluent to river and use the same for irrigation. PHOENIX after carefully studying the overall situation initiated a project in name of **Project Green** to utilize the fully treated effluent, meeting norms set by regulatory authorities, for irrigation.

Project Green Implementation:

This project was started by the participation of the farmers as PHOENIX was not having its own land for this purpose. The farmers were informed and educated about the project and have been given following incentives for the participation in the project.

1. Free treated waste water to irrigate farms
2. Free eucalyptus seedlings and fertilizers
3. Financial incentive of 500 Baht per rai (1 ha = 6.25 rai) per year for four years until eucalyptus is harvested.
4. A guarantee minimum price at 800 Baht per tonne of eucalyptus for a minimum wood yield of 20 tonne per rai for one rotation.
5. Membership in company's medical coverage scheme.
6. Assistance in developing alternative means of income.

Project started in May 1993 and necessary pumping and water distribution facilities were gradually developed and by December 1994 about 2,000 Rai came under this project. Mahasarakham University was appointed to monitor impacts and recommend necessary corrective measures.

Under this project about 60% of waste water generated at PHOENIX for irrigation through the 30 pipe lines put by the company. Due to uneven land area, non availability of land area in big block and variations in soil characteristics etc some problems were faced particularly of seepage and run off water due to excess water in rainy season. In view of experience gained, Khon Kaen University and Mahasarakham University are appointed to evaluate the impacts systematically and recommend the improvement to get better performance of the Project Green. The objectives set for the study for both the universities are given below:

Khon Kaen University, Khon Kaen

1. To study, analyse and survey topography, climate, hydrology and existing environmental impacts.
2. Water use and distribution rates for irrigated plants.
3. Design of water distribution and drainage systems.
4. To propose corrective measures to minimize the impacts.

Mahasarakhan University, Mahasarakham

1. Impact on ground and surface water
2. Long term effects of treated effluent on soil and seepage water.
3. Soil amendment with use of sludge and wood dust.
4. Colour reduction of treated effluent

Various details are being worked out by the experts of the universities, mill personnel and government authorities to run the project effectively.

CONCLUSION

The environmental impacts of pulp and paper production are two folds i.e. consumption of re-

sources and emissions. Water being an important resource requires its optimum utilization through various conservation options as discussed above. At the same time these approaches would result in significant reduction in emissions through waste water in term resulting in cleaner environment. It can be also concluded that many of these approaches which are leading a way for closed loop process will be established as techno-economically feasible and most eco-friendly.

REFERENCE

1. Rapson, WH and Reeve DW, Tappi Jr., Vol 59, No.9, P. 112 (1973).
2. Maples, GE etal, Tappi Jr., Vol 77, No.11, P.71 (1994).
3. Caron, JR and Williams L.D., Tappi Minimum Effluent Mill Symposium, Proceedings, 1996, P. 181.
4. Fuhr, B.J., etal, Tappi Chemical Recovery Conference Proceedings, Atlanta, May 1995.
5. Manolescu, Don, etal, Tappi MEM Sympasium Proceedings, 1996, P.245.
6. Technical literature, Ahlstrom Corp.
7. Mittal, SK and Maheshwari Subhash, IPPTA Convention issue, 1994.
8. Khanna P. etal, "Studies on Pulp & Paper mill waste water soil interactions using lysimeters". A report by NIEM/UNEP Sept 1994.
9. Juwarkar, A.S. etal, Ind Jr. Environ, Health Vol. 27, No. 4, P.313 1987.
10. Environmental Management in Pulp & Paper in Asia and Pacific regions. Finalreport Phase-II NIEM/UNEP, March 1993.