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PERSPECTIVE OF LAND APPLICATION OF TREATED EFFLUENT IN PULP & PAPER INDUSTRY

Nitin Endlay*, D. K. Sharma, Y. V. Singh** , Sarvender Kumar**, K. G. Rosin**, Jitendra Rajput **, Neeta Dwivedi**, Anil Kumar Mishra** & M.K. Gupta***

** Central Pulp & Paper Research Institute, Saharanpur*
*** ICAR– IARI , Delhi*

Abstract: Treated Waste Water Reuse (TWWR) has been gaining importance and momentum in recent years due to depletion of fresh water resources and ever increasing water demand. Considering the need for optimizing the water usage and to supplement the existing resources , it is important to develop suitable strategies and policies to encourage use of appropriately treated water for various non potable purposes. From Indian Paper Industry perspective, land application of treated effluent appears to be a potential option as 90 % of the fresh water consumed by the pulp and paper mills is discharged after appropriate treatment .Moreover, most of the pulp and paper mills are located in rural areas and utilization of treated effluent for irrigation by the farmers can have multifold benefits like saving of ground water, saving in energy consumption during pumping of ground water, less dependence on rain, reduction in overall production cost etc. However without safeguards and scientific approach in place, the unchecked use of treated effluent may lead to health risks to both the water users and consumers as well adverse impact on soil and ground water quality as well as crops . Though studies on impact of treated paper mill effluent on soil , crop and ground water quality have been carried out before also but a systematic and methodical study in this area is still awaited specially in context of significant improvement in overall technological and environmental status of pulp and paper mills in last 6-7 years to meet the stringent discharge norms.

Keywords : TWWR , Sodium Absorption Rate , Effluent Treatment Plant , Best Practicable Technologies

INTRODUCTION

Today with increasing water scarcity, dwindling ground water resources, increasing environmental awareness and efforts to improve river water quality through minimization of industrial discharge into the river, introduction of new regulatory norms on fresh water consumption and wastewater discharge as well as stringent pollution norms in offing, the onus has come upon pulp and paper mills to adopt appropriate strategies and approach. Land application of treated effluent for irrigation / agriculture offers to be a potential options as most of the pulp and paper mills are located in rural areas. As such the treated effluent / waste water discharged by pulp and paper mill is usually accessed informally and in some cases formally by farmers, for irrigation (Fig. 1)

Although data on such informal use in agriculture is not available , the scale is significant, requiring attention to be paid to the transition to a more structured approach. Studies on land application of treated effluent from pulp and paper mills has been carried out in past but that was long back more than 10-12 years when the waste water discharge volume was high as well as environmental compliance was poor leading to adverse impact on soil, ground water

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Figure 1:Utilization of Treated Effluent of by Farmers from Discharge Drain of a Paper Mill for Cultivation of Crops

and crops. With significant improvement in overall technological and environmental status of pulp and paper mills in last 6-7 years specially in context of more than 50% reduction in fresh water consumption and waste water discharge and consequently pollution load due to adoption of best practicable technologies (BPT) like continuous digesters, oxygen delignification, new generation pulp washers, elemental chlorine free bleaching, upgradation of ETPs up to tertiary treatment , mandatory adoption of chemical recovery system by agro based mills due to stringent discharge norms it has become imperative to undertake a systematic and methodical study on the potential of application of treated effluent for agriculture use. It is in this context two leading institutes of the country in field of pulp and paper & agriculture namely **Central Pulp & Paper Research Institute (IARI), Saharanpur (U.P.) India & Indian Agricultural Research Institute, New Delhi** respectively have joined hands to carry out a systematic and methodical study on **Land Application of Treated Effluent from Pulp & Paper Mill and Evaluation of Its Impacts on Soil, Ground Water Properties & Crop Productivity About Indian Pulp & Paper Industry**

INDIAN PAPER INDUSTRY – A BRIEF PROFILE

Indian Paper Industry is unique in terms of scale of operations, diverse types of raw material used and end products produced , status of technology adopted and disparity in quantity / volume of water , steam and energy used . A brief profile of Indian Paper Industry is summarized in Table 1.

Table 1: Profile of Indian Paper Industry

Number of Mills	900
Total Installed Capacity, Million Tonnes	29.11
Operating Installed Capacity, Million Tonnes	23.99
Production of Paper, Paper board and Newsprint, Million tonnes	**21.3**
Wood	**3.91**
Agro residues	**1.16**
Waste Paper	**16.29**

Ref : CPPRI Annual Report 2020-21

Water is fundamental for pulp and paper making. Thus in context of fresh water consumption, Indian paper industry has been traditionally water intensive industry. Though most of the paper making process use water however, around 90% of the water used is discharged as waste water / back water and only 10 % is consumed during the paper making. The major reasons high water consumption are :

- Use of mixed raw materials making optimization of process operations difficult
- Low level of technology and equipments due to low scale of operation
- Lack of optimized process conditions
- Use of low capacity multiple paper machine
- Lack of reuse / recycling practice

In recent years, with increased awareness about water as a valuable resource , savings in energy consumption and reduction in pollution load , scarcity as well as public - regulatory - judicial pressure, most of the pulp and paper mills have significantly reduced fresh water consumption. In general , the pulp and paper mills are / striving to achieve the fresh water consumption & waste water discharge norms as well as effluent norms proposed to be enforced on national level soon as indicated in Table 2 & Table 3.

Table 2: Proposed Fresh Water Consumption & Waste Water Discharge Norms in Indian Paper Industry

Category	Fresh Water Consumption, $m^3/tone_{paper}$	Waste Water Discharge, $m^3/tone_{paper}$
A1: Wood based – Bleached Grades of Papers, Paperboards & Newsprint	50	40
A2: Wood based -Unbleached Grades of Papers and Paperboards	25	20
B1: Agro based- Bleached Grades of Papers, Paperboards & Newsprint	50	40
B2: Agro based- Unbleached Grades of Papers and Paperboards	25	20
C1: RCF based- Bleached Grades of Papers, Paperboards & Newsprint	15	10
C2: RCF based- Unbleached Grades of Papers and Paperboard	10	6
D: RCF & Market Pulp Based Specialty Paper Mills	50	40

Table 3: Proposed Discharge Norms for Indian Paper Industry

Parameter	Unit	Category	
		Integrated Pulp & Paper Mills Producing Chemical Pulp	RCF Based Mills
pH	--	6.5 – 8.5	6.5 – 8.5
Total Suspended Solids (TSS)	mg/l	< 30	< 30
Total Dissolved Solids (TDS)	mg/l	< 1800	< 1600
Chemical Oxygen Demand (COD)	mg/l	< 200	< 150
Biochemical Oxygen Demand (BOD)	mg/l	< 20	< 20
Colour	PCU	< 250	< 150
AOX	mg/l	< 8	-
SAR	--	< 10	< 8

The fresh water consumption in a paper mill depends upon raw material used , end products and number of paper machines.

National Framework on the Safe Reuse of Treated Water

Recently **Ministry of Jal Shakti Department of Water Resources, River Development & Ganga Rejuvenation National Mission for Clean Ganga** has also drafted **National Framework on the Safe Reuse of Treated Water (SRTW)** which is under review by various stake holders . The vision of the framework is to promote widespread and safe reuse of treated used water in India that reduces the pressure on scarce freshwater resources, reduces pollution of the environment and risks to public health, and achieves socio-economic benefits by adopting a sustainable circular economy approach. The Framework envisages a transition towards a situation where farmers safely irrigate with used water, treated to the requisite standard and maintaining nutrients where possible. During this transition, the framework promotes adoption of safer irrigation practices for existing use.

Until recently, used water collection and treatment has been viewed as part of a 'linear' process, but more recently they are being seen as components of a wider circular economy approach, with waste considered as a resource and able to generate revenues. This shift in approach can facilitate cost-effective and fit-for purpose solutions to the prevailing capacity and financial constraints, thereby allowing a faster transition to universal collection and treatment. Treated used water can be reused for landscaping, parks, rejuvenation of wetlands, lakes and ponds to improve the bio-diversity within and around urban and rural centres. As per the recommendation of the Framework , the crops cultivated by farmers in the zone will be strictly regulated based on water availability and food safety considerations. It is in this context **land application of treated effluent** from industry including pulp and paper industry has become more relevant and appropriate to address the vision and objectives of the frame work.

Utilization of Treated Effluent from Pulp & Paper in Industry

In general , the effluent generated in pulp and paper mills is treated comprehensively through exhaustive treatment comprising of equalization tank, primary clarifier , aeration tank, secondary clarifier and tertiary treatment system. While primary and secondary clarifier are used for removal of suspended fibers and biological biomass respectively, degradation of organic matter takes place in aeration tank in presence of oxygen (provided through surface aerators / diffused aeration) and bacterial biomass. Nutrients like DAP / Urea are added in aeration tank to facilitate growth of biological biomass. The layout of general ETP system in pulp and paper mills is indicated in Fig 2 and the various ETP units are depicted in Fig 3, 4 & 5

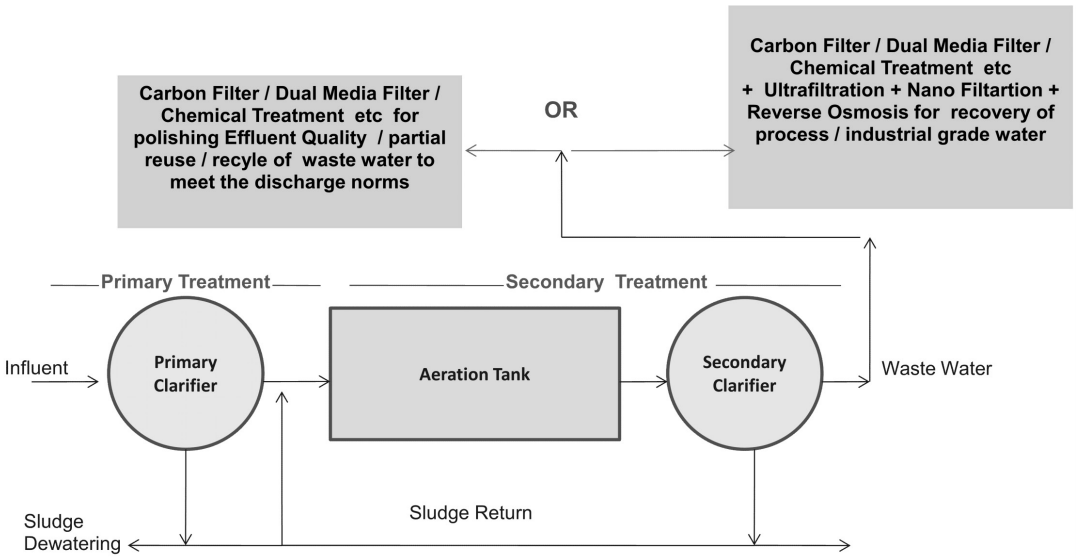

Figure 2: General Layout of Effluent Treatment Plant in Pulp & Paper Industry

Figure 3: Clarifier

Figure 4 Diffused Aeration

Figure 5: Tertiary Treatment

The treated waste water of a pulp and paper mills is usually discharged into the receiving streams. The color in the effluent due to lignin is a major factor of concern in context of discharge into the river. Removal of color / reuse or recycle of treated effluent back into the process require recovery of process water quality from treated effluent through advance treatment including membrane filtration like ultra / nano , reverse osmosis etc. However their techno-economic feasibility is yet to be established and is not very encouraging

Studies have showed that treated effluent from pulp and paper mills contain plant nutrient i.e. nitrogen and phosphorous which can be utilized to grow salt tolerant crops such as wheat, corn, melon, potato, cotton and rice in soil with good drainage facility. The approach has twin advantage as it can address the water related issues of farmers as well as it may enhance the fertility of lands to which it is applied.This type of utilization / application can be considered as an efficient approach for managing / conserving water resources, compensating water shortages caused by seasonality or the irregular availability of water sources for irrigation throughout the year.

Land application of treated effluent appears to be an attractive option for both the mills (in context of disposal of treated effluent) as well as farmers (in context of water availability). However utilization of treated effluent requires critical monitoring of effluent parameters (pH , TSS , TDS, COD , BOD , SAR , Electrical Conductivity, N, P, K etc , heavy metals) , soil properties (Soil texture, bulk density, Electrical conductivity, ESP, C/ N ratio , heavy metals etc) ground water quality (pH, TSS , TDS, COD , BOD, heavy metals , microbiological analysis)) , crop and vegetation (grain yield, vegetable weight etc) to determine desirable and permissible volume for irrigation with treated effluent to avoid any adverse environmental impact.

Treated effluent has frequently accessed informally by farmers, particularly in peri-urban /rural areas inand around paper mills . Although not much data on such informal use of treated effluent in agriculture is vailable, the scale is significant, requiring attention to be paid to the transition to a more structured approach. Without safeguards in place, the critics have reservation that utilization of treated effluent may lead to health risks as well as

- Increase in pH of soil
- Changing soil color & texture
- Imbalance of macro and micro nutrients in soil
- Negative effect on soil microbial activities & disturb all natural cycles
- Decrease in germination percentage
- Adverse effect on seedling growth.
- Increase in organic load
- Depletion of oxygen supply in soil
- Contamination of ground water quality

Thus, it is necessary to ensure the beneficial aspects of this practice before application of treated wastewater in irrigation.

In this perspective **CPCB** has also issued Guidelines for **Utilisation of Effluent in Irrigation** which may serve as a ready guidelines for land application of treated effluent

CPCB Guidelines for Utilization of Effluent in Irrigation

To address the risk of land application of treated effluent, recently Central Pollution Control Board (CPCB) has also issued guidelines for utilization of treated effluent for irrigation / land application . The major guideline include :

(i) The industry should engage an agricultural scientist or tie-up with an agricultural university or institute for advice on the utilization or the rate of application of the effluent for irrigation considering the agro-climatic conditions.

(ii) As seasons and the sowing periods of the crops put restrictions on the utilisation of effluent for irrigation, the industry should prepare a comprehensive **Irrigation Management Plan (IMP),** which should include the following, in consultation with the agricultural scientist or agriculture university/institute and submit to SPCBs/ PCCs which should verify the same while issuing Consent to the industry:
   a. Areas to be covered under irrigation.
   b. Survey/plot (khasra) numbers of land and their area covered in the scheme.
   c. Written agreement with the farmers to bring their land under the scheme.
   d. The quantity of effluent to be used in different periods of the year and cropwise.
   e. The treated effluent distribution system and arrangement for low/no demand period.
   f. Agronomic plan for effective utilization of land.

(iii) The treated effluent should meet the norms prescribed for irrigation under Environment (Protection) Rules, 1986 / Consent. The effluent should also conform to Total Dissolved Solid (TDS)- 2100 mg/l and Sodium Adsorption Ratio (SAR)- preferably less than 18 but not more than 26, depending on soil / crop type, besides meeting any other parameters suggested by agricultural scientist or agricultural university/institute in the IMP.

(iv) Meeting the prescribed norms shall not be the only criteria for use of treated waste water in irrigation, the requirement of water for irrigation will also be a limiting condition which depends upon various factors viz :
   a. **Crop:** This is the main subject determining the water requirement, such as, paddy crops (in general) need more water than trees.
   b. **Climate:** In tropical and subtropical climate especially in arid regions, irrigation frequency is higher. However, in slightly moist conditions the frequency decreases.
   c. **Irrigation type:** There are various irrigation types, namely, flood irrigation, sprinkler, rain gun, drip irrigation, etc., which influences the water requirement for irrigation.
   d. **Soil condition:** The various soil types, such as loam, clay, sandy, clay loam, sandy loam etc., determine the crop types and also alters the irrigation system thus determining the water requirement.
   e. **Soil permeability:** The soil permeability, which is also known as water conductivity of the soil, determines the water retention capacity. This determines the cultivable crops, which in turn determines the water requirement for irrigation.
   f. **Total Salt Concentration**: Total salt concentration (for all practical purposes, the total dissolved solids) is one of the most important agricultural water quality parameters. The plant growth, crop yield and quality of produce are affected by the total dissolved salts in the irrigation water.

v) The command area for effluent utilization should be as near as feasible to the industry in order to facilitate easy monitoring and effective control. The industry should construct a distribution network of impervious conduits to cover the irrigated area.

vi) The industry should construct impervious lined storage tank of minimum 15 days capacity for storage of treated effluent during low/no demand, based on the Irrigation Management Plan.

vii) The treated effluent should be analysed regularly, say after every 15 days. The effluent samples should be taken at the point from where the effluent is discharged for irrigation.

viii) The physico-chemical characteristics of the soil under irrigation with treated effluent, should be monitored twice in a year to assess conditions in summer and post monsoon seasons, in order to determine the deterioration of soil quality.

ix) Similarly, the groundwater quality should also be monitored twice in a year. Samples should be collected from the first water bearing strata from existing hand pumps or by installing the same for sampling purpose only. The sampling points should be uniformly spread in the command area and near effluent storage area.

x) The industry should carry out the analysis of various prescribed effluent/soil/ground water quality parameters from the NABL/ EPA/ SPCBs/PCCs recognized /accredited laboratories.

xi) Reports regarding compliance of effluent quality standards and status of soil and ground water quality shall be submitted to SPCBs/PCCs twice in a year, in first week of January and July.

xii) In case of observation of any deterioration of the soil and groundwater quality parameters in the assessment by agricultural scientist or agricultural university/institute, the application of effluent should be stopped immediately and the industry should inform the SPCB, accordingly. The industry shall be solely responsible for reclaiming the soil and water quality at their cost in the affected area.

Land Application of Treated Effluent from Pulp & Paper Mill and Evaluation of its Impact on Soil, Ground Water Properties & Crop Productivity (Joint Project of CPPRI & IARI)

To address the issue of land application of treated effluent with fresh approach specially in context of CPCB guidelines on the issue and draft National Framework on the Safe Reuse of Treated Water a joint project on **Land Application of Treated Effluent from Pulp & Paper Mill and Evaluation of its Impact on Soil, Ground Water Properties & Crop Productivity** has been initiated by two leading institutes of the country namely **Central Pulp & Paper Research Institute , Saharanpur (U.P.)** & **ICAR - Indian Agricultural Research Institute** with two leading pulp & paper mills (agro based and wood based). The project aims to carry out a systematic and methodical study potential of use of treated effluent for irrigation purpose backed by consolidated and proven data base on the impact on soil and ground water quality as well as crops productivity specially in context with the improvement in quality of treated effluent generated from pulp and paper mills and improvement in over all environmental and technological status of pulp and paper mills witnessed in last 6-7 years. specially with adoption of **Bare Minimum Technology** or **Best Practicable Technology** and ETP up gradation up to tertiary level and mandatory adoption of chemical recovery system by all agro based pulp & paper mills with modern application techniques. The impact on pollution load due to technological up gradation are indicated in **Table 4 and Table 5.**

This significant reduction in pollution load in treated effluent due to adoption of modern fiberline technologies gives a boost to prospects of increased used of treated effluent for irrigation of crops in a sustainable way without impacting soil , ground water and crop quality Under the joint project just initiated jointly by CPPRI & IARI WTC field experiments have been / are being designed with modern water application

Table 4: Impact of Oxygen Delignification on Pollution Load Generation

Chemical Consumption & Pollution Load in Conventional Chlorine based Bleaching Sequence (Without ODL)		Chemical Consumption & Pollution Load in Conventional Chlorine based Bleaching Sequence (With ODL)	
Chlorine as Elemental	48 – 50 kg/T	Chlorine as Elemental	25 – 28 kg/T
Chlorine as Hypo	12 – 15 kg/T	Chlorine as Hypo	8 – 9 kg/T
Caustic	35 kg/T	Caustic	26 – 28 kg/T
COD	2600 mg/l	COD	1800 mg/l
BOD	847 mg/l	BOD	700 mg/l
AOX	13 mg/l	AOX	6.5 mg/l

Table 5: Reduction in Pollution Load through Adoption of Chemical Recovery

S. No.	Parameters	Average Reduction in Pollution Load	
		Mills without Chemical Recovery Plant	Mills with Chemical Recovery Plant
1	COD	800 - 1000 kg/ton of paper	60 - 80 kg/ton of paper
2	BOD	450 - 550 kg/ton of paper	24 - 32 kg/ton of paper

techniques like, **micro-sprinkler, drip and sub-surface drip irrigation** for application of the treated paper mill effluent based crop production The selection of the crops, design of experiments and collection of inputs, arrangements for field layout,collection of data pertaining to the efficacy of different irrigation systems, crop management aspects are underway for conduction of field experiments (Fig 6).

Figure 6: Ground Water & Soil Sampling at a Selected Site for Field Study

The study will be carried out at two selected site in around pulp & paper mills for a project period of 5 years The paper mills selected are an agro based writing and printing grade integrated paper mill located in Punjab & another wood and agro based integrated pulp and paper mill in Uttrakhand . Two types of land applications of treated have been planned namely **Bare soil & Cropped lands** with 5 kinds of dilution / mixing ratio viz 20%, 40%, 50% , 60% , 80% & control (100% fresh water). The study will be carried out in both cropping season i.e Rabi and Kharif for at least three years with 6 crops i.e. 3 in Rabi and 3 in Kharif for three years. The types of crops have been selected based on water requirements i.e.

- Low Water Requirement Crops – LWRC (Mustard and Pearl Millett)
- Medium Water Requirement Crops – MWRC (Wheat and Maize)
- High Water Requirement Crops – HWRC (Sugarcane and Paddy)

The **quantified deliverables** of the study are expected to be multi dimensional and include:

- Determination of the amount and rates of treated paper mill effluent that can be safely applied in 2 different types of soils (light and heavy soils) without land degradation.
- Evaluation of soil quality and pollutant assimilation capacity/index based on soil analysis.
- Estimation of cut off time (years) for continuous application of paper mill effluent in agriculture.
- Estimation of safe application rate and quantified information of appropriate mixing ratios for 6 different crops without compromising economic yield and quality of the produce.
- Estimation of pollutant removal rate by six different type of selected crops and their safe limits.
- Study of absorption status of various elements (including heavy metals) by different crops and their safe limits for future recommendations.
- Evaluation of positive impacts such as yield enhancement/ reduction in plant nutrient requirement/ soil fertility build up and other benefits of land application of treated paper mill effluent on agricultural land as well as negative impacts (if any) on soil, crop, ground water and environment.
- Evaluation Ground water pollution status and technologies for safe harvesting of PME in different types of tanks.
- Evaluation of Microbial load (positive / negative).
- Evaluation of environmental impacts (odour removal / reduction) and other ecosystem services of land application of pulp and paper mill effluent (by protection of surface and ground water resources from direct application of paper mill effluent in water), ecological benefits etc. .

CONCLUSION

Systematic & Methodical land application of treated effluent is beneficial to farmers in terms of their dependence on ground water / rain water . The strategy is also beneficial in terms of recharge of ground water / conservation of ground water table .Pulp and Paper mills where 90% water used is discharged can be of potential help to nearby farmers in terms of utilization of treated effluent by farmers. However there is a need to provide guidance to farmers on types of crops cultivated which are safe for consumption and have high demand or provide revenue that meets farmers expectations. In this context regular monitoring of ground water , soil and crops quality is also must to prevent or timely check any adverse impact on soil and ground water quality. In both agriculture and agroforestry end uses, there should be assured commitment from pulp and paper mills on the quantity and quality of treated waste water supplied. In addition it is also important to develop and apply advanced decision support system based on theoretical /conceptual, empirical and computational approaches, models, techniques and tools to help understand the synergies and tradeoffs in the water and waste water management and make scientifically based water management decisions. The joint collaboration of CPPRI – IARI for the study of land application of treated effluent is a

systematic and methodical approach and step in this direction which ultimately is expected to help in water conservation as well as benefit various stake holders including farmers as well as industry leading to overall improvement in rural economy.

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