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POTENTIAL IRRIGATION COMMAND OF PULP AND PAPER MILL TREATED EFFLUENT UNDER CONVENTIONAL AND PRESSURIZED IRRIGATION TECHNIQUES - A CASE STUDY#

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Abstract: The demand for freshwater resources has increased among the various water sectors, which has increased pressure on the available freshwater resources. Groundwater is the prime source to meet the irrigation sector demand, which has caused in lowering of the water table. The increased water demand of distinct water-consuming sectors requires exploration of alternate water sources for sustainable development.The pulp and paper mill treated effluent has great potential in the irrigation sector. The present investigation described the potential of pulp and paper mill treated effluent for safe use in irrigation in the Nainital district, Uttarakhand state, under different irrigation techniques. A treated effluent source having a capacity of generating 25,000 cubic meters per day was chosen in the present case study. Results revealed that the potential irrigation command utilizing treated effluent for wheat crop would be 793.4, 1057.9, and 1190.2 hectares under conventional, sprinkler, and surface drip irrigation techniques, respectively.Similarly, for rice, mustard, sugarcane, maize, and cotton, the potential area was 388.3, 986.4, 233.9, 1738.1, and 730.0 hectares, respectively, under conventional irrigation system. The highest potential command was found for mustard crop due to low water requirements and most inadequate for rice crop due to high water requirements. This study implies the huge potential to safely utilize treated effluent in the irrigation sector. Direct and conjunctive ways of effluent utilization in the agriculture sector need to be ascertained for safety concerns.

Keywords: Pulp and paper mill, effluent, irrigation, potential irrigation command, agriculture

INTRODUCTION

Water is a crucial component of agricultural productivity and contributes to food security. Water resources are used by humanity for drinking, municipal purposes, and various commercial activities. Irrigated agriculture is typically more productive per unit of land than rainfed agriculture, allowing for greater production escalation and crop diversification.

Competition for water resources is predicted to intensify due to population expansion, urbanization, and climate change, with a specific impact on farming.

Presently, treated wastewater is seen as a potential water resource due to its high nutritional content, which may be advantageous to plant life (Mishra and Behera, 1991); as a result, the utilization of wastewater in farming is fast gaining popularity. The paper industry in India is among the largest, utilizing a significant quantity of freshwater (Trivedy and Raj, 1992). Approximately 75 to 95% of the water was released as effluent comprising organic and inorganic contaminants and colorants. Numerous researchers have conducted research on the influence of paper mill effluent on different crops (Choudhury *et al*., 1987; Dutta and Boissya, 1996,1999, 2000). Baruah and Das (1997) mentioned that paper mill effluent treatment delays, retards, and decreases rice seed

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#Based on the preliminary analysis

germination and seedling growth in contrast to control. Rajannan and Oblismai (1979) found that paper mill effluent has a detrimental effect on rice sprouting, black gram, and tomato seeds, but that diluted effluent (25 and 50%) increases growth. Karande and Ghanvat (1994) mentioned that dilute effluent had little influence on the general growth characteristics of pigeon pea seedlings treated with paper mill effluent.

The literature cited described the application of treated pulp and paper mill effluent in agriculture crops. However, no studies have been conducted to quantify the potential irrigationcommand utilizing pulp and paper industries effluent for irrigation purposes. Therefore, in the present investigation, an attempt has been made to estimate the potential irrigation command for different crops grown in the Lalkuan, Nainital district, Uttarakhand.

2. MATERIALS AND METHODS

The theoretical study was undertaken for the Lalkuan block of Nainital district, where Century Pulp and Paper Mill are situated. The Century Pulp and Paper Mill, Lalkuan, Nainital (Uttarakhand) located at about 7 km from G.B. Pant University of Agriculture and Technology, Pantnagar, on the Bareilly Nainital highway. Meteorological data of the past 10 years considered to calculated reference evapotranspiration and crop demand subsequently. The lalkuan block is dominated by clay soil. Nainital district is blessed with ample monsoon rainfall, but most of it flows out as runoff. The cropping pattern is a diversified type. Cultivated principal crops include rice, wheat, sugarcane, mustard, and maize.

2.1. Analysis Scenario

To quantify the area that can be brought under irrigation using treated pulp and paper mill effluent has been estimated considering different irrigation methods. Irrigation infrastructures are responsible for the utilization of water in the field. A properly designed and operated irrigation system increases irrigation efficiency and optimum crop production. Irrigation system efficiency under surface/conventional irrigation systems is usually poor, resulting in water loss. Simultaneously, pressurized irrigation systems have higher irrigation efficiency and thus more crop production. This article considers irrigation efficiency of 60 % (which is usually for groundwater irrigation/tube well irrigation) and 80 % & 90 % for sprinkler and drip irrigation, respectively.

2.2. Effluent discharge availability

The effluent discharge capacity of 25,000.0 cubic meters per day has been considered to work out the potential area which can be brought under irrigation facilities. This effluent discharge rate has been assumed for the whole year so that different crops, which are generally taken by the farming communities, can be irrigated during a different season.

2.3. Reference evapotranspiration

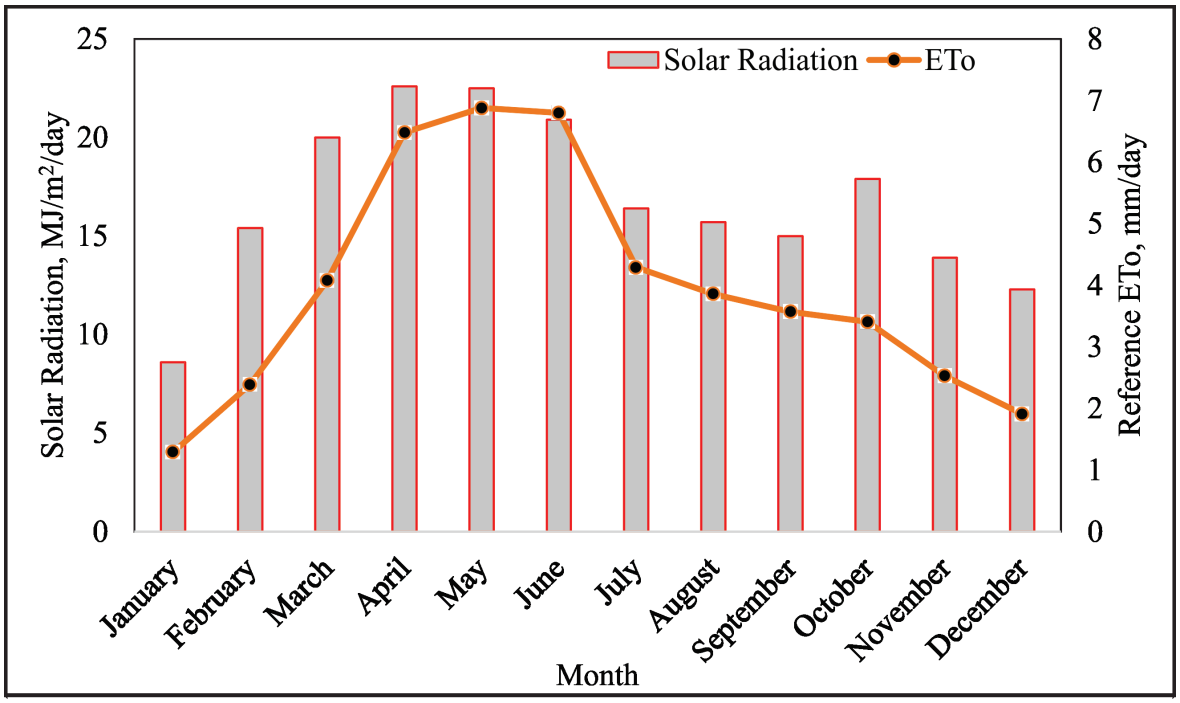
Using the Penmen-Monteith method, reference evapotranspiration (ETO) was calculated using CROPWAT monthly. Monthly net crop irrigation requirements were calculated using CROPWAT 8.0 (FAO, 1992). CROPWAT 8.0 for Windows is a computer program for computing crop water requirements and irrigation requirements from existing or new climatic and crop data. Furthermore, the program allows the development of irrigation schedules for different management conditions and the calculation of scheme water supply for varying crop patterns based on data provided by the user. These data can be directly entered into CROPWAT or imported from other applications. Researcher Rajput *et al*. (2017) employed CROPWAT 8.0 software to estimate crop water requirements in the Bhimsagar canal command system. Table 1 shows the meteorological parameters.

3. RESULTS AND DISCUSSION

Reference evapotranspiration values obtained for the district have been displayed in figure 1. The value of daily reference evapotranspiration was found minimum (1.29 mm/day) in January and maximum in May, with a value of 6.88 mm/day. The average value of reference evapotranspiration was obtained as 3.96 mm/day. This shows a huge variation in the reference evapotranspiration values during different months.

Table 1: Meteorological parameters in the study area

Month	*Min Temp*	*Max Temp*	*Humidity*	*Wind*	*Sun*
	°C	*°C*	*%*	*km/day*	*hours*
January	6.9	16.5	83	98	3
February	8.9	23.7	71	103	7.4
March	14.3	31.7	61	120	8.9
April	18.8	39.1	42	168	9.2
May	23.3	37.8	48	204	8.4
June	25.5	38.2	51	206	7.2
July	25.6	32.4	78	178	4.3
August	25.5	31.6	81	151	4.3
September	23.6	30.4	83	122	4.8
October	18.6	31.8	67	65	8.9
November	13.7	27.5	67	67	7.6
December	6.8	23	69	70	7.1
Average	17.6	30.3	66	129	6.8



3.1. Net irrigation requirement (NIR) of crops

Net irrigation water requirements for different crops cultivated in the study area were estimated considering the effective rainfall during the crop growing season. The highest net irrigation requirement was found for sugarcane crops with a value of 780 mm during the entire growing season. The net irrigation requirement for the

Table 2: Net irrigation requirement and potential irrigation command of pulp and paper mill treated effluent

Crop Name	*NIR (mm)*	*Irrigation methods*		
		Surface	*Sprinkler*	*Drip*
Wheat	230	793.4	1057.9	1190.2
Rice	470	388.3	517.7	582.4
Mustard	185	986.4	1315.3	1479.7
Sugarcane	780	233.9	311.9	350.9
Maize	105	1738.1	2317.4	2607.1
Cotton	250	730.0	973.3	1095.0

wheat crop is estimated to be 230 mm. The net irrigation requirement (NIR) for other crops is shown in table 2. Rainfall and effective rainfall distribution during different months (1 to 12 stands for January to December) are shown in figure 2.

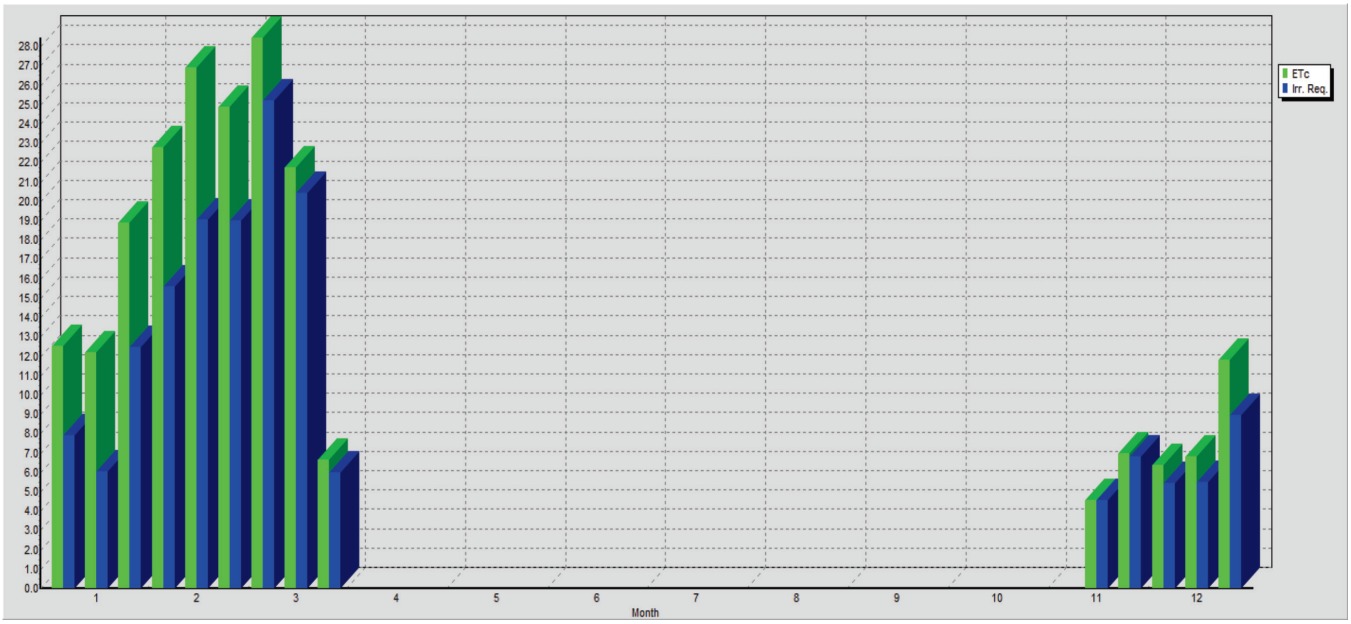


Figure 2: Rainfall and effective rainfall during different months

3.2. Potential Irrigation Command using Treated Pulp and Paper Mill Treated Effluent

The potential irrigation command using direct application of treated pulp and paper mill effluent has been worked out for six crops. Results revealed that the potential irrigation command utilizing treated effluent for wheat crop would be 793.4, 1057.9, and 1190.2 hectares under conventional, sprinkler, and surface drip irrigation techniques, respectively. Similarly, for rice, mustard, sugarcane, maize, and cotton, the potential area was 388.3, 986.4, 233.9, 1738.1, and 730.0 hectares, respectively, under conventional irrigation system. There was a significant increase in the potential irrigation command under pressurized irrigation techniques, and the highest command which can be created was under drip irrigation techniques. Under sprinkler irrigation system, the potential irrigation command can be created for rice, mustard, sugarcane, maize, and cotton was 517.7, 1315.3, 311.9, 2317.4, and 973.2 hectares, respectively. Under the drip irrigation technique for rice, mustard, sugarcane, maize, and cotton, the potential irrigation command was 582.4, 1479.7, 350.9, 2607.1, and 1095.0 hectares, respectively. The highest potential command was found for mustard crops due to low water requirements and the lowest for rice crops due to high water requirements.

4. CONCLUSIONS

There has been increasing demand for water by different sectors in recent times. The agriculture sector depends on groundwater to full fill the irrigation need. However, the faster depleting of groundwater tables and drying of the aquifers due to excessive withdrawal and inadequate natural recharge have threatened the agriculture production system's sustainability. To overcome such challenges, pulp and paper mill treated effluent holds great potential to meet the irrigation sector's demand. The study demonstrated that substantial area can be brought under irrigation by utilizing the treated effluent as a water source. Proper irrigation scheduling and optimum irrigation amount should be worked out to use treated effluent in the agriculture sector safely for different crops.

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