

# Water Required to Satisfy Indian and Global Paper Demand using Sugarcane Bagasse as Raw Material

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**Abstract:** *The aim of this study is to determine the water requirements for cultivating sugarcane crop and its usage in the paper/pulp industry. Bagasse is a dry pulpy by-product obtained from crushing sugarcane. The demand for paper in India is booming, hence what fraction of this demand can be met through sugarcane bagasse is identified. The quantity of water required to obtain bagasse was found. The preferability of bagasse pulp over hardwood pulp for paper production has been explored. The demand for paper globally and amount of water used to produce one ton of paper using bagasse has been determined. Finally, the benefits and limitations of papermaking from bagasse have been discussed and some solutions regarding them have also been proposed.*

**Key Words:** *Sugarcane bagasse, Global paper demand, Water requirement, Paper production.*

## 1. INTRODUCTION:

Water is a fundamental requirement in human life. Millions of people face water scarcity on a daily basis and lack access to clean water. Therefore, it has become a global concern save water wherever possible. People are trying to find methods to maximize production while minimizing the usage of water.

Paper production is a process which requires a lot of water. Water is used in almost all. The consideration of water consumption for production process only would be incorrect. Rather, this issue should be approached from a life cycle perspective and include all the processes (upstream and downstream) of the supply chain [1]. So, we evaluate the direct water consumption in every stage as well as the water consumed indirectly in various processes like: chemical preparations, transportation, coal washing, supply for cooling and boiling for power generation etc. Consequently, freshwater storage is depleting because of the usage of water to produce paper.

Another problem faced in the paper production is the quantity of raw materials required. A huge amount of wood is consumed in the paper making process. The exact quantity is unknown because a large amount of wood used for this purpose is imported from developing countries and that value is unaccounted as it is carried out through various unorganized channels. A large paper mill can process over 3 million tons of wood each year. In 2011, there were 80 mills in US (Southeast) only drawing wood from the region and the industry was producing over 120,000 tons of pulp in a day [2]. High use of wood also gives rise to various climatic problems. To overcome this, the use of wood per year needs to be less than the forest growth rate or wood production rate per year.

In India, the demand for paper is increasing, while forest based raw materials are rapidly depleting. The raw materials used in paper production can be forest-based or agro-based cellulose [3]. To resolve the situation of depleting forest cover, the Indian government is exploring the agro-based cellulose raw material alternatives. Subsequently, the usage of forest-based raw material has declined from 84% to 43% (1970 to 1994) while the agro-based material has increased from 9% to 32% during the same period. A suitable replacement for forest based raw material is bagasse.

Bagasse is classified as a biodegradable waste product with highly limited uses. It is the product that is left behind after crushing sugarcane stalks to extract their juice and is the dry pulpy fibrous fraction. The paper produced from bagasse meets the requirements of paper as bagasse has good sheet formation and has smoothness of paper [4]. Apart from its uses in paper and pulp industry, it can be utilized as biofuel. However, due to high smoke and moisture content, the efficiency is low. Globally, only around 5 per cent of the total paper produced is made from bagasse. However, this number is increasing each year. Bagasse is generally used to produce printing, writing, tissues, photocopier paper, newsprints and packaging boxes [5]. Papermaking using bagasse helps the environment at multiple levels: The waste product (bagasse) is utilized efficiently and the handling and disposal problem of this waste is minimized. Also, a huge number of trees are saved each year.

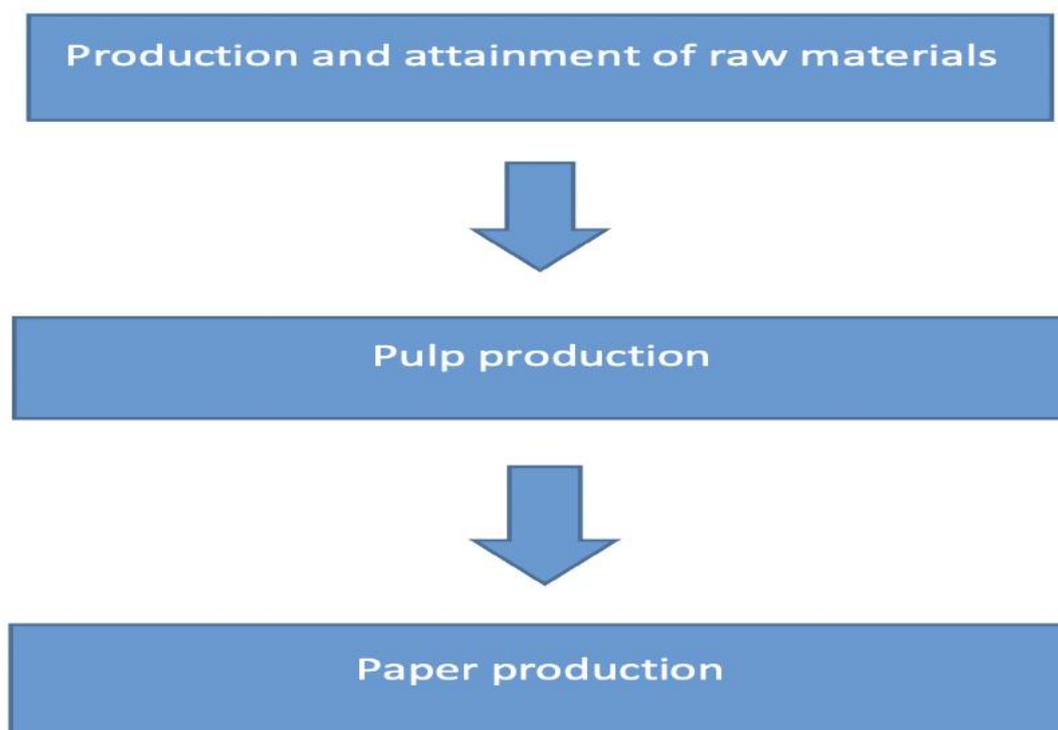
It is to be noted that the crop water requirements of a hardwood (eucalyptus for example) are not very high as compared to sugarcane. However, the reason bagasse should be used for paper production is that it is not used entirely for paper making. First, sugar products like jiggery, sugar, etc. are produced. The residue (bagasse) is used as a fuel in the sugarcane industry and the final leftover bagasse is sent for paper production. In the case of hardwoods, the crop is

exclusively grown for paper industry. In simple terms, a certain amount of water to sugarcane crop will give sugar products, fuel and paper whereas almost the same amount of water to a eucalyptus will give only paper.

### 1.1. Paper production process:

In the production of paper, the journey starts from the planting of the crops that are used as raw materials to the finished goods being consumed (Fig.1). The process of paper production involves the following process [6].

- Raw Material Preparation
- Pulping
- Pulp Washing
- Pulp Screening, Cleaning and Fractionation
- Bleaching
- Paper Making



*Figure 1:* Process of paper production

This paper aims in analysing the water usage in the production of paper in India using sugarcane waste, bagasse, as raw material. The usage of water both in the production of sugarcane and in the paper making is found.

## 2. METHOD:

The following quantities have been calculated in this study:

- Water consumption and production of sugarcane crop in India and the state-wise distribution.
- Amount of paper that can be produced using the current sugarcane cultivation in India.
- Amount of water required to produce 1 ton of II quality paper using bagasse.
- Area of sugarcane crop needed to satisfy the Indian paper demand if the entire paper production has to be done using bagasse.
- Area of sugarcane crop needed to satisfy the global paper demand if the entire paper production has to be done using bagasse.

## 3. FINDINGS:

### 3.1. Water Consumption and Production of Sugarcane Crop in India:

The water required by existing area of sugarcane crops has been calculated using software CropWat 8.0. The water requirement for each state was found by using the location of the major sugarcane producing area in that state. The area of production and total amount of sugarcane for the year 2017- 18 were taken from Directorate of Sugarcane Development [7].

State	Water (mm)	Area (x10 <sup>5</sup> ha)	Water Required (m <sup>3</sup> )	Production (x10 <sup>5</sup> tonnes)
Andhra Pradesh	1630.10	0.99	1613799000	79.48
Assam	1105.20	0.30	331560000	11.15
Bihar	1279.90	2.43	3110157000	165.11
Chhattisgarh	1448.00	0.30	434400000	12.47
Gujarat	1542.90	1.84	2838936000	122.34
Haryana	1606.70	1.14	1831638000	87.29
Jharkhand	1269.60	0.07	88872000	5.23
Karnataka	1541.90	3.70	5705030000	299.02
Kerala	1534.30	0.01	15343000	1.22
Madhya Pradesh	1378.10	0.98	1350538000	54.30
Maharashtra	2020.60	9.02	18225812000	726.37
Odisha	1421.60	0.05	71080000	3.41
Punjab	1444.10	0.93	1343013000	75.33
Rajasthan	1881.20	0.05	94060000	4.04
Tamil Nadu	1986.30	1.83	3634929000	165.62
Telangana	2094.80	0.35	733180000	22.17
Uttar Pradesh	1867.40	22.34	41717716000	1623.38
Uttarakhand	1867.40	1.02	1904748000	71.42
West Bengal	1376.10	0.17	233937000	12.94
Others	1794.59	0.19	340971425.1	8.68
Total		47.71	85619719425	3550.97

**Table 1: Area, water required and production of sugarcane in India**

From the table we see that:

- i. The total area of cultivation of sugarcane in India is 4.771 Mha.
- ii. The total production of sugarcane is  $3.55 \times 10^8$  tons.
- iii. The total water required for the production of sugarcane is  $8.56 \times 10^{10} \text{ m}^3$ , i.e.,  $8.56 \times 10^{13} \text{ l}$ .
- iv. The yield of sugarcane produced in India is  $(3.55 \times 10^8 \text{ tons} / 4.771 \text{ Mha}) = 75.28 \text{ tons/ha}$ .

### 3.2. Amount of Paper That Can Be Produced Using the Current Sugarcane Cultivation in India:

The quantity of sugarcane produced in India is  $3.55 \times 10^8$  tons. 100 tons of sugarcane can give 4 tons of bagasse that can be directly used in paper production [4].

Therefore,  $3.55 \times 10^8$  tons of sugarcane will give  $(3.55 \times 10^8 \times 4) / 100 = 1.42 \times 10^7$  tons of bagasse.

Around 1900 kg (1.9 ton) of bagasse gives 1 ton of paper [8]. Therefore  $1.42 \times 10^7$  tons bagasse will give  $(1.42 \times 10^7) / 1.9 = 7.47 \times 10^6$  tons of paper.

### 3.3. Amount of water required to produce 1 ton of paper using bagasse:

On comparing values obtained in the above point and Table 1, we can deduce that to produce  $7.47 \times 10^6$  tons of paper, the water required is  $8.56 \times 10^{10} \text{ m}^3$ , i.e.,  $8.56 \times 10^{13} \text{ l}$ . Therefore, water required to produce 1 ton of paper =  $(8.56 \times 10^{13}) / (7.47 \times 10^6) = 1.146 \times 10^7 \text{ l/ton of paper}$ .

For industrial purposes, around 80 tons of water is used in different steps like washing, diluting, etc. [8]. Therefore, water consumed for industrial usage is 80 tons, i.e.,  $8 \times 10^4 \text{ l/ton of paper}$ .

Therefore, the total water consumed for producing 1 ton of paper =  $1.146 \times 10^7 + 8 \times 10^4 = 1.154 \times 10^7 \text{ l/ton of paper}$ .

### 3.4. Area of sugarcane crop needed to satisfy the Indian paper demand if the entire paper production has to be done using bagasse:

The annual paper demand in India for the year 2018 was  $17.2 \times 10^6$  tons [9].

Around 20% of this paper is produced using bagasse [10], which is  $0.2 \times 17.2 \times 10^6$  tons =  $3.44 \times 10^6$  tons. It is evident from the above calculations that the sugarcane cultivation in India is sufficient to meet the domestic paper demand. If the annual paper demand of India has to be satisfied entirely from bagasse, the hectares of sugarcane crop needed is:

Annual paper demand in India (2018) =  $17.2 \times 10^6$  tons  
 Bagasse needed to satisfy this demand =  $17.2 \times 10^6$  tons  $\times$  1.9 =  $3.26 \times 10^7$  tons.  
 Sugarcane needed to obtain  $3.26 \times 10^7$  tons bagasse =  $3.26 \times 10^7$  tons  $\times$  (100/4) =  $8.15 \times 10^8$  tons.  
 Land area required to produce  $8.15 \times 10^8$  tons sugarcane (considering the mean national yield = 74.5 tons/hectare) =  $(8.15 \times 10^8 \text{ tons})/74.5 = 1.09 \times 10^7$  hectares  
 The current national cultivation of sugarcane is  $4.771 \times 10^6$  hectares. This means in order to meet the annual paper demand by using bagasse alone the current crop cultivation needs to be more than double.

**3.5. Area of sugarcane crop needed to satisfy the global paper demand if the entire paper production has to be done using bagasse:**

The countries that are the major producers of sugarcane are Brazil, India and China [11]. Table 2 shows the global distribution of sugarcane production.

Country	Area (Mha)	Production (million tons)
Brazil	5.343	386.2
India	4.608	289.6
China	1.328	92.3
Thailand	0.97	64.4
Pakistan	1.086	52
Mexico	0.639	45.1
Colombia	0.435	36.6
Australia	0.423	36
USA	0.404	31.3
Philippines	0.385	25.8
Indonesia	0.35	25.6
Cuba	0.654	22.9
South Africa	0.325	20.6
Argentina	0.295	19.2
Myanmar	0.165	7.5
Bangladesh	0.166	6.8
<b>Total</b>	<b>17.576</b>	<b>1161.9</b>

**Table 2: Country-wise distribution of sugarcane production**

From the table we find:

- i. The total area of production is 17.576 Mha.
- ii. The total production is 1161.9 million tons.

Therefore, the yield of production can be taken as  $(1161.9 \times 10^6 \text{ tons}/17.576 \text{ Mha}) = 66.1 \text{ tons/ha}$ . The amount of paper that can be produced from this is:

Bagasse produced =  $1161.9 \times 10^6/25 = 46.476 \times 10^6$  tons

Paper produced =  $46.476 \times 10^6/1.9 = 24.46 \times 10^6$  tons

The annual global paper demand for paper was found to be 414 million tons [12]. If we are to satisfy this demand by using bagasse the area required for production of sugarcane can be calculated as follows.

Annual global demand =  $414 \times 10^6$  tons

Bagasse needed to satisfy this demand =  $414 \times 10^6 \text{ tons} \times 1.9 = 78.66 \times 10^7$  tons

Sugarcane needed to obtain  $78.66 \times 10^7$  tons bagasse =  $78.66 \times 10^7 \text{ tons} \times (100/4) = 1.97 \times 10^{10}$  tons.

Land area required to produce  $1.97 \times 10^{10}$  tons sugarcane (considering the mean global yield = 66.1 tons/hectare) =  $(1.97 \times 10^{10} \text{ tons})/66.1 = 297 \times 10^6$  hectares.

The current global cultivation of sugarcane is  $17.576 \times 10^6$  hectares. This means in order to meet the annual paper demand by using bagasse alone the current crop cultivation needs to be increased more than 16 times.

#### 4. RESULT:

- The total water required for the production of sugarcane in India is  $8.56 \times 10^{10}$  m<sup>3</sup>, i.e.,  $8.56 \times 10^{13}$ l.
- The yield of sugarcane produced in India is  $(3.55 \times 10^8 \text{ tons} / 4.771 \text{ Mha}) = 75.28 \text{ tons/ha}$ .
- Amount of paper that can be produced using the current sugarcane cultivation in India =  $7.47 \times 10^6$  tons of paper.
- Amount of water required to produce one ton of paper using bagasse =  $1.154 \times 10^7$  l/ton of paper.
- Area of sugarcane crop needed to satisfy the Indian paper demand if the entire paper production has to be done using bagasse =  $1.09 \times 10^7$  hectares.
- Area of sugarcane crop needed to satisfy the global paper demand if the entire paper production has to be done using bagasse =  $297 \times 10^6$  hectares.

#### 5. DISCUSSION:

The water required for making paper from sugarcane bagasse in India is  $1.154 \times 10^7$  l/ton of paper. It should be noted that the case here is of ideal situation. Not all the bagasse that are produced are made into paper. Part of it is used as bio fuels. Using bagasse as bio fuels should be discouraged as, along with reducing the quantity available for producing paper, it causes pollution too.

The hardwoods that are used in paper production are grown exclusively for paper production which is not the case of sugarcane. The water used for paper making through bagasse, when accounting net consumption, is too low as compared to hardwood. It is because bagasse is a waste product for a process, whose final products are sugar, sugar products like jiggery and paper. For a hardwood tree used for making paper, the water usage should be taken completely for paper production whereas in paper production using bagasse, the water is in credit as we already obtain a completely useful product, i.e., sugar and related product.

The global demand for paper and paper wood is forecasted to grow with an annual average growth rate of 2.8% [13]. Therefore, by 2030 the global demand will reach around 630 million tons. From the above calculations, it is very clear that the current sugarcane cultivation can hardly satisfy the total paper demand. Also, the amount of paper that can be produced by entirely using sugarcane bagasse is very minuscule. Therefore, due to these reasons, it can be concluded that sugarcane yield needs to be maximized by the help of modern technologies.

#### 6. RECOMMENDATIONS:

In the bagasse-based paper and pulp industry it is a common drawback that it tends to generate large volumes of high strength wastewater, which can cause pollution to the environment without proper chemical recovery and economically viable pollution control measures. It is recommended to integrate pollution prevention techniques at the source prior to the end-of-line wastewater treatment plant. The common solutions that could be implemented are [3]:

- Installation of Multiplex Filter for the Wire Pit
- Installation of Separate Tank and Pump for Edge Cutting Nozzles
- Double Felting
- Water Conservation
- Fibre Recovery
- Solar Evaporation of Concentration Black Liquor
- First Stage Cooking Using Black Liquor
- Raw Material Cleaning

The import of sugarcane or bagasse is not suggested because this may help a particular region but the global paper produced from bagasse would remain the same. The water consumption in the entire paper making process cannot be further reduced as it may then affect the various paper making processes. However, it is suggested to plant sugarcane crops either near to water sources like rivers or places of high rainfall. It is because a sugarcane crop generally uses large amounts of water. Therefore, the virtual water remains same in all cases but this solution helps to avoid the region from becoming water stressed.

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