



## Research Article

### Handmade Paper from Recycled Paper Stock Collected from DTU

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#### Abstract

Waste paper constitutes an excellent low cost and high quality fiber source for the papermaking industry. Limitations in the application of conventional to such paper are related to negative environmental impacts. The methodology initiated with the preparation of the waste paper samples that were used for the execution of the subsequent processes i.e. the defibrization process; the repulping process; the execution of flotation; the papermaking procedure; and finally the evaluation of paper properties. The pulp yield is high and it is 91.72%. This may be because already it is treated to remove the lignin content and the recycled paper is rich in hemicelluloses. The resultant characterization also indicates the obtained handmade paper is of good quality and it could be used for variety of uses ranging from writing, printing to drawing.

**Keywords:** Waste paper; Recycling; Handmade Paper; Paper properties.

#### Introduction

Paper is one of the basic needs of modern life. It is a well-known product and it is used as the medium of communication for writing. Moreover, it is used in every walk of life ranging from education to entertainment and in arts and crafts [1]. The handmade papers may be converted into different items for daily use such as bags, files, folders etc. Now-a-days there is a good market for handmade paper since the products of handmade are eco-friendly, free from destructive chemicals and non-Toxic. It's also an employment generative activity. It's one of the preferred industries since investment is comparatively lower than any such allied industrial units. At the same time this handmade unit has potential to generate good profits. Use of recovered paper as raw material for new paper is an important means for reducing waste and effective utilization of available resources, and is therefore has considerable social importance. On the one hand, it is well known the paper production has enormous effects on the environment [2]. The usage and the processing of raw materials have a variety of negative effects on the environment. On the other hand, there are technologies which can moderate the negative impacts on the environment and they also have a positive economic effect. For

instance one of the best and most effective processes is recycling. The paper production from the recycled fibers calls for less energy utilization; conserves the natural resources like wood and decreases the environmental pollution. Moreover, the conflict between economic optimization and environmental protection has received wide attention in recent research programs for waste management system planning [3-7]. Even though, the handmade paper production process is labour intensive, but it has very good specific market targeting artists and handmade product production.

The present work aims to check the feasibility of handmade paper production from the waste paper collected from Debre Tabor University (DTU). Secondly, the handmade paper is characterized for its effective utilization after its production [6-10]. Table 1 gives the range of values of various properties of paper that are available in the market. This table is used as a reference for the experiment carried out in this work.

#### Materials and Methods

The waste papers were collected from various departments of Debre Tabor University and stored for further processing (Figure 1). The methodology was initiated with the preparation

of the sample [11]. In order to enhance the quality of results and to avoid any damages to the equipment used in the processing.

Table 1. Properties of paper

Paper Properties	A4 Paper values (80 GSM A4 paper)	Values
GSM ( $\text{g/m}^2$ )	80	60 -120
pH	7.5	7.5 - 10
Density ( $\text{g/cc}$ )	0.75	0.25 - 1.52
Thickness (mm)	0.108	0.07 - 0.18
Bulk ( $\text{cc/g}$ )	1.33	4 - 0.658
Moisture Content (%)	8	6 - 8

### Sorting and dusting

The raw material that is to be used is manually sorted and foreign materials ranging from stapler pins to office clips and threads were removed. To remove dust and dirt the material was shaken vigorously.



Figure 1. Waste paper collection and size reduction

### Repulping and Screening

The precleaned papers were cut into smaller size as shown in Figure 1 and fed to the mixer blender for repulping. Agitation by impellers breaks the paper down more quickly into fibers slurries. Eventually, the old paper turns into a mushy mixture called pulp. The pulp is forced through screens containing holes and slots of various shapes and sizes. The screens remove small contaminants such as bits of plastics, coarse sands, office pins, glasses and other

contaminants if present. This process is called screening.

### Deinking process

Deinking is one way to remove the coloring matter or to clean stained raw materials. Ink is flaked off, dispersed, suspended, and separated from fibers in wastepaper by using mechanical power in addition to alkali and chemicals such as surface-active agents. For 100 g of pulp approximately 5 g of sodium hydroxide is added.

### Pulp yield

The formed pulp was filtered and made into pulp ball and dried in the oven at  $50^\circ\text{C}$ . The bone dry weight of the pulp was recorded by following standard oven drying method. Then the dried pulp was left at the room temperature overnight and then weighed and used for further calculation. The pulp yield is calculated by using the following formula.

$$\text{Pulp yield} = \frac{\text{weight of the dry pulp}}{\text{Initial weight of the sample}}$$

### Web formation

Measured quantity of the dry pulp was taken and repulped with known quantity of water. This pulp was poured into a tub which already contains water. Using mold and deckle arrangement and dipping method the pulp was collected over the screen, shaken evenly and excess water was allowed to drain (Figure 2). However, in large scale production the consistency of the pulp in the tub should be maintained constantly. Then the sheet of paper from the screen was transferred to couch sheet. Similarly four to five sheets were formed and arranged one over the other separated by couch sheet. Then this arrangement was pressed uniformly to remove any water that adheres to the sheet of paper.



Figure 2. Paper formation and final paper (colored paper prepared by addition of methyl orange and methylene blue dye)

### **Drying**

Even after the sheets have been pressed, they still contain about 50% to 65% of the moisture. Hence the formed paper was successfully separated from couch sheets and air dried at room temperature. Solar dryers can speed up the process. However, it is mandatory to dry the colored sheets under shade.

### **Cleaning and Sizing**

Small particles of dirt and other foreign matters present on the surface of the paper were removed manually with a sharp instrument. The cleaned sheets are coated with a layer of starch to improve the quality of the paper and prevent feathering. This process is called sizing. This starch coating was carried out manually using a brush and the papers were dried once again.

### **Calendaring and cutting**

After 48 hr the papers were heat pressed to give uniform and wrinkle free surface. Then the papers were cut according to standard say A4 or A5 size. This paper was subjected to further analysis.

### **GSM( basis weight)**

The weight per unit area expressed as  $g/m^2$ , also called as grammage is the most fundamental property of paper and paperboard. Paper is sold by weight but the buyer is interested in the area of paper per given weight. The paper manufacturer always strives to achieve all desired paper properties with the minimum possible grammage.

$$G = \frac{M}{A}$$

Where M=weight of paper

A=surface area of paper

### **pH value**

The paper is cut into small pieces, mixed with water and the pH of the solution was recorded.

### **Paper density**

The structural density of paper, the grammage divided by the structural thickness expressed as  $kg/m^3$ , is also an important property in paper-making with wide use in paper

$$\text{Density}(\rho) = \frac{G}{L} = \frac{M}{V}$$

### **Thickness**

It is expressed in mm using caliper tester. Measures the uniformity of fiber distributed on paper tray that is uniformly distributed fiber have consistent thickness throughout paper tray. Thin paper is more susceptible to be tear, easily damaged with Hand moisture/ humid air, low scratch resistance & low resistant to applied pressure beyond certain limit.

$$T = \frac{\sum tn}{n}$$

Where n=1, 2, 3...

### **Bulk**

The bulkiness of the paper is calculated by the ratio of grammage per unit thickness.

### **Moisture content**

All the samples are kept in the oven for 60 min at 110°C and left in the laboratory overnight to attain the equilibrium moisture content. Next day the moisture content is calculated as per the formula

$$\text{Moisture content} = \frac{\text{Moisture amount}}{\text{Weight of paper}}$$

## **Results and discussion**

### **GSM Test**

GSM was calculated for three types of recycled paper. Addition of  $CaCO_3$  and starch increased the grammage value. It can be seen that the GSM ratio is higher for 5% of  $CaCO_3$  and 5% of starch.

### **pH Test**

From the Table 2 it is clear that the value of pH increases with the addition of  $CaCO_3$ .

### **Density Test**

The resultant density of the handmade paper increases with the increased addition of  $CaCO_3$ . This is evident from the Table 2.

### **Thickness Test**

The maximum thickness is found to be in the paper where the raw material alone is present. The thickness of the paper decreases with the addition of  $CaCO_3$ , this may be due to the good finishing obtained by the additives with less quantity of pulp.

### **Bulk Test**

The higher the bulk value the quality of the paper is good. The lowest bulk value is found in

the paper where the  $\text{CaCO}_3$  and starch value is 2% in the presence of additive.

### Moisture Test

It can be seen from the above Table No. and Figure No. that with the addition of  $\text{CaCO}_3$  the moisture content of the paper is decreasing. The moisture content of the paper is in the range of writing paper.

Table 2. Properties of handmade paper

Hand made Paper	Recycled waste paper		
	Raw material only	2% $\text{CaCO}_3$ & 2% starch	5% $\text{CaCO}_3$ & 5% starch
GSM ( $\text{g/m}^2$ )	112.12	112.23	112.42
pH	7.6	7.8	7.83
Density (g/cc)	0.740	0.758	0.769
Thickness (mm)	0.112	0.1105	0.110
Bulk (cc/g)	1.351	1.352	1.361
Moisture Content (%)	7.69	7.52	7.48
Pulp yield (%)	91.72	91.72	91.72

### Conclusions

In the present work recycled paper stock was used as raw material to produce handmade paper. Due to the presence of high alpha-cellulose content and less lignin content the paper production process requires less treatment and is a good raw material for the production of handmade paper under lab conditions or factory conditions. From the study it is clear that the addition of additives like  $\text{CaCO}_3$  and starch improves the quality of the final finished paper.  $\text{CaCO}_3$  acts as filler and gives white color to the paper, whereas starch helps to bind the paper. And it can be concluded from the values of the properties that the handmade paper from recycled paper has the quality of writing paper. Utilization of recycled paper stock as raw material for handmade paper saves money. It reduces greenhouse gas emission because waste papers are not burnt and hence eco-friendly. Small business units can be developed for the pulp production and in due course the pulp import in Ethiopia could be reduced. This will create job as well as will remove some waste from its source.

### Conflicts of interest

Authors declare no conflict of interest.

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