PAPER PRODUCTION FOR ROUGH USE FROM AQUATIC WEEDS (*Limnocharis flava*) AND ITS EVALUATION

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Abstract

Paper recycling cannot be per

Although Paper recycling is beneficial solution to Sri Lanka, it can not be done continuously by using recycled papers. The tensile strength decreased 13% in the first cycle and 20% after four cycles of recycling (Zhang, 2003). The fiber content is reduced, when papers are recycled repeatedly. Therefore, every time, papers are recycled, the fiber component should be added to it.

Cotton, grasses, sugar cane, straw, weeds (Aquatic weeds), etc. could be used for the providing of virgin fiber for paper recycling (Joedodibroto et al., 1983). When aquatic weeds are considered, those are problematic plants to agriculture sector in Sri Lanka. Because aquatic weeds rapidly grow and widely spread under favorable tropical climate condition and it becomes nuisance. Covering the water surface results many agricultural and irrigational problems, bringing the undesirable flavors in water together with other health hazards. The reduction of velocity of water flow and increasing of siltation and the reducing the carrying capacity of water bodies are major problem identified due to rapid growth of aquatic plants in water bodies.

Among the various kinds of aquatic weeds, yellow velvet leaf (*Limnocharis flava*) is more common in Sri Lankan water bodies. Fiber content of yellow velvet leaf is 52.6% and lignin content is 7.71% (Catalo and Eberhardt, 2007).These parameters are considerably higher comparing with other aquatic plants. Because of that reason, in this study, it was attempted to produce and evaluate the recycled papers using discarded paper mixing with above aquatic weeds for rough use.

2. MATERIALS AND METHOD

The experiment was conducted at small scale paper production institute, in Yatiyana. The harvesting of weeds for the experiment was done at the paddy field and water reservoir at proper maturity stage. Harvested aquatic weeds were cleaned by washing to remove impurities, cut to small pieces and dried. The moisture percentage after drying was ~25%. Physical properties of harvested aquatic weeds were tested at the laboratory. Waste papers (discarded books) were also used for this experiment.

2.1 EXPERIMENT DESIGN

The experiment was designed as Complete Randomized Design (CRD). Total number of treatment was seven with five replicates. According to the decided ratio (Table 2.1) waste papers and LF were mixed to produce paper. Only discarded paper was used as a control.

Table 2.1: Treatment allocation

Waste Paper Proportion (%)	LF Proportion (%)	Treatments
100	-	T1
80	20	T2
60	40	T3
50	50	T4
40	60	T5
20	80	T6

2.2 PAPER PRODUCTION

Waste paper and prepared aquatic weeds were mixed according to treatment ratio (1 kg of dry matter). Twenty liter of water and raw material mixture were added to the beater.

Then mixture was beaten for 40 min. After beaten Alum ($Al_2(SO_4)_3.18H_2O$), (20g), Starch (20g), Rosin ($C_{19}H_{29}COOH$) (20g), were added in to mixture and again mixture was beaten ~ 20 min.

A fixed amount of the pulp (1500g) was poured evenly onto a hand-sheet lifting mold (mesh on a wooden frame), which immersed in water tub, and poured pulp was gently agitated with finger strips for even distribution of fiber over a wire mesh of mould. The mould was then raised keeping horizontal position to drain the excess water. After that, wooden frame of hand-sheet lifting mold was removed and placed the paper sheet with mesh on a cloth, which spread on leveled wooden plate, as paper sheet attach to the cloth. The wire mesh was slowly pressed by hand to the cloth and then removed wire mesh from that paper sheet. The produced bulk of hand-sheet were pressed until removing excess water by using pressure machine and kept on hanger for three days to dry well. After drying, papers were subjected to calendaring to get smoothness and glossy of papers.

2.3 DATA OBSERVATION

After preparation of papers according to different ratio of LF and waste paper, they have to be evaluated for selecting a suitable ratio. The some of physical properties which are popularly used for the evaluation of papers and strength were used.

Grammage, weight per unit area, were determined at the laboratory using analytical balance and vernier caliper. Grammage value expressed as g/m^2. The size of the paper used in this test was 20cm×20cm.

Moisture content was determined gravimetrically after drying the sample in drying oven. Moisture content expressed as percentage to fresh weight.

Micrometer was used to measure the perpendicular distance between two surfaces. Thickness was expressed as mm.

Surface water absorption by produced paper was determined by using Cobb test apparatus. Surface water absorption 60 seconds were determined by using Cobb testing apparatus and it is expressed in g/m^2. Specimens were cut to 12.5 cm × 12.5 cm squares as free from folds, wrinkles, or other blemishes. Prepared specimens were weighed to the nearest 0.01 g and placed on a dry rubber ring on the metal plate of apparatus. Then metal ring was placed on the specimen, and fasten placed the crossbar (or other clamping mechanism) to prevent any leakage between the ring and the specimen. Hundred milliliters of water was poured into the ring as quick as possible to giving a head of 1.0 cm to metal ring. After 2 minute, specimen was removed from apparatus and placed between blotters and roller twice with the roller (10kg) to remove excess water. Then sample was weighted to the nearest 0.01g and determined the water absorption by equation 1.

$$Cobb\ value\ (g/m^2)\quad (W_{after}\quad W_{before})\quad 100 \quad (1)$$

Where, $\boldsymbol{W_{after}}$ is sample weight after 2 min (g) and $\boldsymbol{W_{before}}$ is **s**ample weight before kept apparatus (g).
Water absorption at the end of the paper edge was also determined. Wick test was adopted for (TAPPI, 2001). Paper surface was sealed with waterproof tape on both sides, weighed, placed in water at 27^0C for 20 minutes and weighed again to measure the water absorbed. Equation 2 in used for the calculation

$$\text{Water absorption, kg/m}^2 \quad \frac{\text{W}_{\text{After}}\text{(g)}\quad \text{W}_{\text{Before}}\text{(g)}}{\text{A, cm}^2} \quad 10 \quad (2)$$

Where, W_{After} is weight of sample after 20 min (g), W_{Before} is weight of sample before placed in water (g) and A is area of sample (cm^2).

Tearing resistance (Elmendorf tear test) is very important for papers. It is the maximum hydrostatic pressure required to rupture. It is expressed as mN. The Elmendorf tear tester (TAPPI, 2001) was used to measures tearing strength of specimen. The change in height of the pendulum after it "tears" through the specimen was detected and converted to tear strength.

Breaking strength was expressed as N/cm^2. Paper strips of 0.5cm × 20 cm were prepared as samples. One side of paper strip was attached to the table and weight was added to the bucket to other side until it breaks. Breaking strength was determined by using equation 3 (Richerd, 2000).

$$Breaking\ strength,\ N/M \quad \frac{Total\ weight\ (Bucket \quad Weight)\ at\ the\ breaking\ of\ strip, N}{Width\ of\ strip, m} \qquad (3)$$

3. RESULTS AND DISCUSSION

3.1 GRAMMAGE

The results the grammage of papers are shown in figure1.Treatment 5 (LF 60%) shows highest mean value (504g/m^2) and it is significantly difference from others at the 0.05 probability level. Treatment 2 shows minimum mean value of grammage (272.22 g/m^2).Those are significantly different from treatment 1 where only waste paper are used to produce pulp.

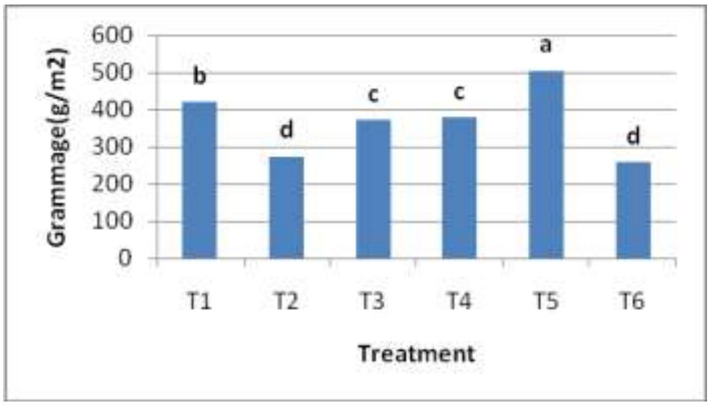

Figure 1: Grammage of Produced Different Papers

Second highest gramage value was determined in to control, where only discarded papers are used. When papers are purchased as weight bags, high gramage papers gives low surface area.

3.2 MOISTURE CONTENT

Moisture content of different papers produced are shown in figure 2.It is clear that the changes in moisture content does not have any consistent relationship with LF percentage used for the paper production. However, lower moisture percentage was observed in treatment 1 where only waste papers are used while higher values was noted in treatment 6 where higher percentage of LF was used. Higher moisture content may increase the weight of paper. Fungal growth can also be influenced by the higher moisture percentage. The moisture percentage of treatment 1,3,5 do not significantly different from each other.

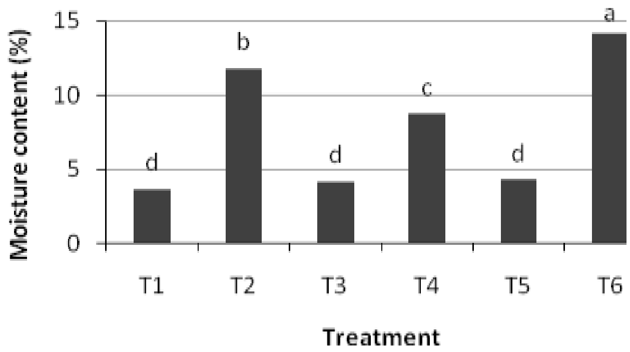

Figure 2: Moisture content of Different Papers

3.2THICKNESS
Highest thickness can be identified in treatment 5 that produced from waste paper 40% and ,LF 60%. Thickness values all types of papers produced are significantly different 5% probability level. Treatment 5 shows slightly higher value for thickness with control. However, these values are significantly different. Lowest thickness value shows in the treatment 2 where 80% of discarded papers are used.

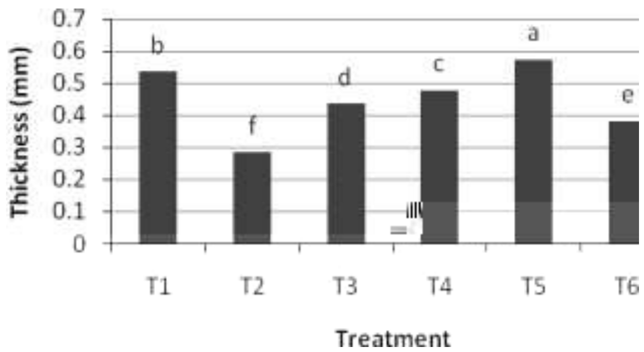

Figure 3: Thickness of Produced Papers

3.3 MOISTURE ABSORPTION FROM SURFACE (COBB)
Treatment 5 shows highest Cobb value (474.4 g/cm^2) than other treatment and it is significantly different from other treatment at 0.05 probability levels. Lowest Cobb value is 71.4 g/cm^2 and it shows by treatment 2 (LF 20%) also it significantly different from other (figure 4).

When increasing LF in pulp , Cobb value increased from 71.4 g/cm^2 to 474.4 g/cm^2 and then the value decreased with further increasing of LF % in pulp (figure 4).

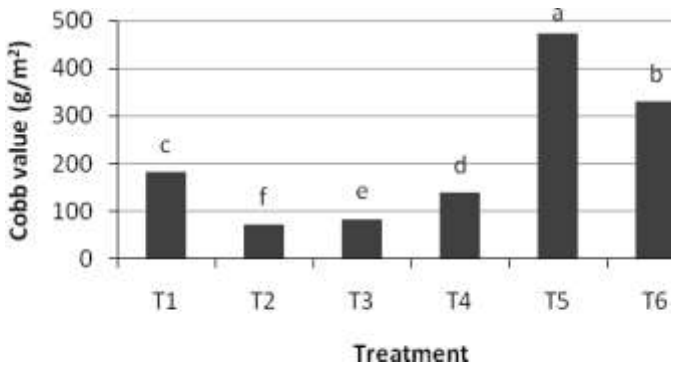

Figure 4: Moisture Absorption from Surface of Paper

3.4 MOISTURE ABSORPTION FROM EDGE (WICK)

Highest moisture absorption from edge shows in treatment 6 (0.875 kg/m^2). Lowest value is shown by treatment 2 which is mixture of waste paper 80%, L:F 20% (0.0636 kg/m^2).According to results it is clear that moisture absorption is increased with increasing of LF in pulp.

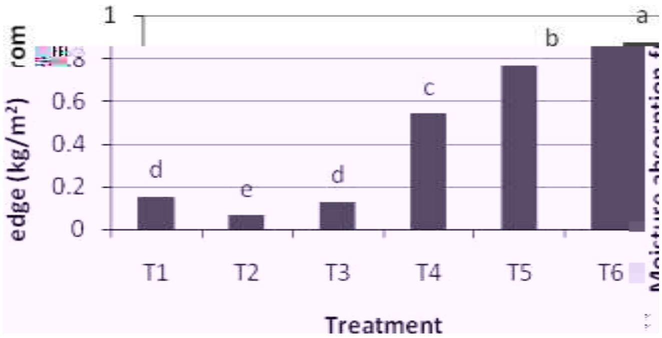

Figure 5: Moisture Absorption from Edge of Paper

If the paper sheets have wavy edges moisture absorption is high and paper sheets with tight edges have low moisture absorption ability. Treatment 1, 2 and 3 are not significantly different in terms of moisture absorption by edge of the paper.

3.5 TEARING RESISTANCE

The tear strength measures the ability of the sheet to resist the propagation of a tear. Treatment 5 shows highest tearing resistance (3160mN) and also it significantly different from other treatments. The lowest tearing value (1760mN) is shown by treatment 6 papers, but it not significantly different from treatment 2.

From treatment 2 to 5, when increasing LF percentage in pulp, tearing resistance is increased. If it is further increased, tearing resistance decreased (figure 6). It is apparent that addition of more LF is increased the tearing resistance. However, further increase of LF over 60%, tearing resistance reduced significantly. Treatment 5 and 1 show high tearing resistance, however, they were significantly different at 5% probability level.

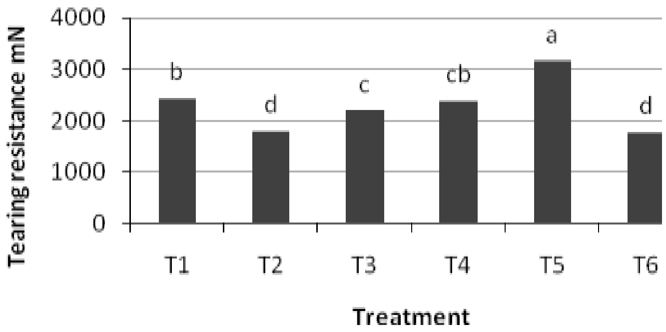

Figure 6: Tearing Resistance of Paper

3.6 BREAKING STRENGTH

Breaking strengths of produced papers are shown in figure 7.The highest breaking strength (4621mN) was noted in the treatment 5 where 60% of LF was used. The second highest values were observed in control; however it is significantly different from treatment 5.Treatment 6 (LF 80%) shows lowest breaking strength (1092.4mN) and it is significantly different from other treatments.

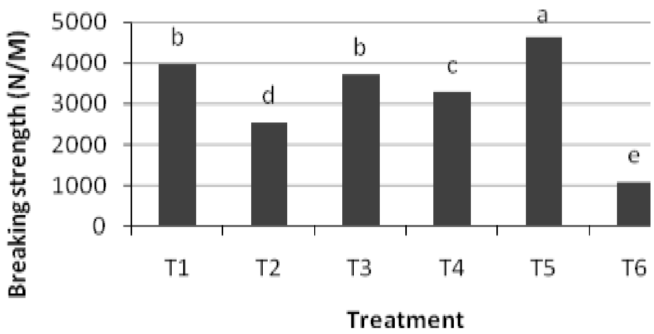

Figure.7: Breaking Strength of Paper

As a rule of thumb, the breaking strength increases with decrease in tearing resistance (Caulfield and Gunderson, 1988). Because of at high inter fiber bonding levels; there is a higher degree of fiber fracture. At lower bonding levels, more fibers are pulled out. Therefore, in breaking strength, fiber tends to be pulling out than fracture.

4. CONCLUSIONS

Papers that are produced from waste paper, with 60% of LF as virgin fiber, without separation of fiber from lignin in to pulp, can increase the strength properties (Tearing resistance, Breaking strength),compared with same properties of recycled paper. However, moisture absorption is quite high in paper produced from discarded paper and LF (60%). Due to high strength properties, produced paper using 60% of LF can be used for the hard use such as file covers and bags etc. The moisture absorption could be reduced in this paper by adding suitable filling materials.

Therefore, when considering the strength properties of papers produced from 60% of LF as virgin fiber without removing of lignin from fiber and without any chemical pre treatment can be recommended for paper production in hard use.

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