



COMBATING ENVIRONMENTAL DEGRADATION THROUGH RESOURCE RECOVERY OF 'WASTED RESOURCE' – A MICRO LEVEL STUDY

\*Gayathri, D. and Visalakshi Rajeswari

Department of Resource Management, Avinashilingam Institute for Home Science and Higher Education for Women University, Coimbatore – 641 043

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ABSTRACT

A paperless society is a dream come true. Paper – an essential resource but a paradoxical material -is not considered environment friendly and increase in use has contributed to global deforestation, contamination of water, soil and air. All activity economic or human can come to a halt if this resource become absent in the world. World consumption of paper has gone up 400 per cent in the last forty years for which nearly four billion trees or 35 per cent of the total trees cut around the world have been used by paper industries in all the continents. The most efficient way to conserve any resource is to recover the 'resources out of waste'. Paper recycling refers to converting waste paper back into usable paper products. India being an agrarian economy, agro wastes (wasted resources) also mount high and contribute their mite to spoil the environment. An attempt was made through a micro level study to utilize both these wasted resources to produce paper – a 'recovered resource', which will benefit both the society and environment. Value addition of such 'recovered resource' was also tried. This article delineates the procedure adopted and salient findings of the study.

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INTRODUCTION

*"The earth has enough resources to meet the needs of people but will never have enough to serve their greed."*

- Mahatma Gandhi

Among the economic indicators of the country paper assumes great importance. Man has found many uses for paper in the form of paper board which has a myriad of secondary uses like wrapping, packaging, toweling, insulation and photography<sup>1</sup>. The amount of paper that passes through one's hands each day is massive, let alone the amount of paper that is daily thrown away. Paper is a bit like oxygen - it's all around but almost nobody notices. Paper is a substance composed of fibres interlaced into a compact web, which can then be macerated into pulp, dried and pressed, a quality that quantifies paper well for recycling<sup>2</sup>. For every one tonne of mill made paper approximately 300 trees are cut for one tonne of paper board, 2.5 to 3 tonnes of dry forest based materials are required. The consumption is expected to grow by an additional 6-8% annually<sup>3</sup>. This sustained demand, especially of the advanced countries has resulted in continued denudation of forests causing severe environmental imbalances. The digital – era, much contrary to the scientists' being of a paperless society accounts rather for 155 billion sheets of paper used per year worldwide<sup>4</sup>. India too is in the race; the need for paper is expected to rise to 4 Kg per person per year.

With an increasing population and increasing use of paper, the only true environmentally sound alternative is reduction in consumption of paper by all<sup>5</sup>. And what is the most feasible alternative? Recovery and reuse of a large proportion of the waste material produced by modern society is a silverline; as the ability to turn refuse into a resource presents a key opportunity for growth. Alternatively it is no longer enough to manage a waste and minimize the environmental impact of its treatment. As Vaish (2008) said waste must be used as a resource. The most efficient way to conserve resources is to use goods for longer periods of time or to reuse them after they have served their original functions<sup>6</sup> thus paving way for 'recovering the lost resource'. Bulk paper making is a huge industry consuming whole forests of trees every year, so making old paper products new again is important<sup>7</sup>. For this, it is necessary to 'recover the resource' out of the waste. Paper recycling is the process of converting waste paper (post-consumer) or scrap paper (pre-consumer) into a usable product. Resources crunch would become a serious problem unless resources are also generated from waste materials. Therefore, it is time that human belief start believing in the following adage and act accordingly to reduce waste, but 'recover the resources in waste', be it paper or agro waste.

*Waste is a wealth potential  
Waste is a threat to environment and life  
Waste is a nuisance to the society, but  
Waste is also a challenge to meet.*

\*Corresponding author: [gayathri\\_3nov@yahoo.co.in](mailto:gayathri_3nov@yahoo.co.in)

With this backdrop an attempt was made through a micro level study to utilize both these wasted resources to produce paper –

a 'recovered resource', which will benefit both the society and environment

## MATERIALS AND METHODS

Recovery of the embedded resource is the need of the hour. Channelizing endeavors to satisfy this component should be the primary objective of all research projects. Post consumer paper is a major waste disposed off into the solid waste stream. It is both an environment hazard as well as a wasted resource. To tackle both the problems and to use the wasted resource, making handmade paper as a cottage industry may sound is the only a plausible solution. Such an attempt was made. The details are given below.

**Mini project on paper making:** An attempt was made to produce paper by pulping post consumer paper in the laboratory premises. The study was carried out in the Resource Management laboratory of Avinashilingam University for Women, Coimbatore. Using the two methods - manual and mechanical - different types of post consumer wastes that could be pulped, the paper to pulp ratio, quantum of recyclable waste and recoverable resource, suitability of the same for making consumer utility products and the like were analyzed. The machinery used for making recycled paper was a mechanical pilot paper plant comprising of the various component machines.

**Recourse recovery for post consumer paper:** Experimental studies involving other post consumer paper wastes like photo copy sheets (paper), brown sheet, card board box, tissue paper, news paper, magazine paper, scrap (printing press waste) and coloured paper were also tried in the conventional method. Combining agro wastes like banana waste for their paper yielding potentials were also attempted. Quality enhancement and embellishment of recycled paper using different additives was also carried out. So waste paper and banana waste (rich sources of fiber) were combined for making paper. Laboratory trials have shown that these wastes can yield unbleached pulp-the material needed for making paper.

**Value Addition of Post Consumer Paper:** 'value addition' of any waste being the catch phrase in the recent years, the exercise on incorporating value to recycled paper was stream lined on the following lines

**Products of Commercial Value:** Value addition was tried on paper and paper products recovered from all kinds of fibre wastes, post consumer paper wastes and pulp. Feasibility of these recycled wastes for recovery into consumables was thus determined. To this effect, consumer utilities, stationery items and articles for household décor were made.

**Products of Industrial Value – Paper Crete:** Incorporation of post consumer paper waste as pulp to the components of the hollow blocks in different permutation combinations was attempted. The product obtained using different blends was also tested for strength.

## SALIENT FINDINGS

The findings of the action oriented mini project are presented under the following headings.

### 1. Feasibility for Resource Recovery

2. Recycling to Recover the Resource – Paper
3. Recycling other Agro Fibres to Make Paper
4. Satisfaction of Paper - Specific Characteristics
5. Value Addition of Recycled Paper

### 1. Feasibility for Resource Recovery

Attempts at reducing paper waste and other agro wastes by recovering their latent wealth was ventured by carrying out experiment adopting conventional and mechanical methods (paper plant). The salient findings are:

#### Repulping

Repulping of post consumer waste (paper waste) alone was done adopting two different techniques is presented under Table 1. The study revealed that the pulp obtained from use of post consumer paper and other wastes in different combinations proved very functional and fruitful, as the pulp generated was quite considerable in both the methods. It also made clear that the recyclable component in all the types of paper waste tried was considerably a good yield.

### 2. Recycling to Recover the Resource - Paper

Recycling of waste is the conversion of waste into reusable forms, such that the waste is no longer a waste, but a resource used for optimum productivity<sup>8</sup>. With this viewpoint the pulp obtained was recycled to produce paper again. Table 2 gives details on the quantum of recycled paper realized and the physical details of the paper realized through recycling. Studies have proved that almost 80 per cent of the paper component can be recovered from post consumer paper in the process of repulping, though recovered paper contains some fibers which have become too small to be recycled into paper. The present study has also proved the same. Recovery of paper was within the range of 74 – 83.5 per cent from different types of post consumer paper, proving recovery is a feasible endeavour. As cardboard boxes, tissue paper, magazine paper, news paper and coloured paper available in the market are already made of recycled paper the yield from them was found to be comparatively low. An earnest effort from all quarters of the society would pave way for fruitfully recovering paper waste into useful paper, paper boards and products for local consumer use and as an employment generation sector, and an environmental protection venture. In the conventional method of recycling paper alone, variation in the shape, thickness and amount of paper used was introduced and it was found that under domestic conditions (handmade paper) itself it was possible to produce paper of varying shapes, dimensions, weight and thickness. The study also brought to light that variation could be introduced in the weight of the paper based on the raw material used for recycling. Based on the weight of the paper produced the number of paper obtained differed. In the mechanical method, paper was produced to satisfy for standard paper dimensions. This analysis proved that, it is possible for small entrepreneurs to produce paper and boards, if at all, one could marshal resources for establishing the enterprise which can definitely prove a profitable means of earning money.

### 3. Recycling other Agro Fibres to Make Paper

There are some plants that can serve the pulp function whose yield is far higher than that of the tree, and whose growth

Table 1. Quantum of Post Consumer Waste Used and Pulp Obtained

Technology Adopted	Waste Chosen	Quantum of Waste Used (in gms)	Water Used (in ml)	Pulp Obtained (in gms)
Conventional Method	Note book paper	50	900	1000
	Photo copy sheet	50	700	950
	Card board box	50	750	950
	Scrap paper	50	800	950
	Tissue paper	50	850	950
	Brown sheet	50	700	900
	Coloured paper	50	850	900
	Magazine paper	50	750	850
	News paper	50	700	800
Mechanical Method (Paper Plant)	Post consumer paper	10 Kgs	140 litres	170 Kgs

Table 2. Details and Quantum of Recycled Paper Realized

Technology adopted and Waste Used	Quantity of Recovered Waste (in gms)	Number of Paper Produced	Shape of the Paper Produced and Total Number	Weight of each Recycled Paper	Thickness of Paper (mm)	Dimensions of the Paper (diameter in mm)	Weight of Recycled Paper (in gms)	Per cent of Recovery
Conventional Method								
Note book paper	50	8	Circle	15 gm	39	19	41.75	83.5
Photo copy sheet	50	7	"	7 gm	37	19	41.5	83
Card board box	50	8	"	6 gm	30	19	41.5	83
Brown sheet	50	5	"	10 gm	29	19	40	80
Tissue paper	50	7	"	9 gm	20	19	39.5	79
News paper	50	5	"	6 gm	35	19	38.5	77
Magazine paper	50	8	"	11 gm	25	19	38	76
Scrap paper	50	6	"	15 gm	35	19	37	74
Coloured paper	50	7	"	8 gm	40	19	37	74
Mechanical Method								
Writing Sheets	10 Kgs	25 30	Rectangle (55)	240gm 70 gm	1.25 65	50X60 25X20	8.1kgs	81

Table 3. Details on Other Fibres Used in Handmade Paper Making

Permutation combinations of waste used	Quantum used (gms)	Water used (in ml)	Pulp obtained (in gms)	Number of paper produced	Weight of recycled paper (gms)	Per cent of recovery
Conventional Method						
Paper + Bagasse	50 +10	800	1000	8	45.9	76.5
Paper + Cotton	50 +10	750	950	8	45.6	76
Paper + Coir waste	50 +10	800	950	7	45.3	75.5
Paper + Jute waste	50 +10	700	900	7	44.1	73.5
Paper + Rags	50 +10	750	900	7	43.2	72
Paper + Saw dust	50 +10	700	850	6	43.2	72
Paper +Banana stem	50 +10	700	850	6	42	70
Paper +Jute +Rags	50 + 5 +5	750	800	5	40.8	68
Paper + Jute + Banana	50 + 5 +5	650	750	5	39.6	66
Banana alone	60	600	700	5	37.2	62
Mechanical Method						
Paper + Banana	10+2½ Kgs	100 litres	150 Kgs	170	9.62 Kgs	77

Table 4. Properties of Handmade Paper

Waste Used	Techniques Adopted	Type of Recycled paper	Type of Paper	Gsm	Formation	Properties Considered	
						Absorbency (sizing)	Opacity
Post Consumer paper	Conventional Method	Writing Sheets	Circular	70	Well formed	1.6 cm in 4 sec	Opaque
			Rectangle	80	Thin spots	1.3 cm in 3 sec	Opaque
		Photo copy sheet	Circular	78	Well formed	2 cm in 23 sec	Opaque
		Card board box	Circular	150	Well formed	1.1 cm in 5 sec	Opaque
		Brown sheet	Circular	100	Well formed	0.7 cm in 2 sec	Opaque
		Tissue paper	Circular	135	Thick spots	0.8 cm in 1 sec	Opaque
		News paper	Circular	56	Well formed	1.8 cm in 2 sec	Opaque
		Magazine paper	Circular	75	Thick spots	1.1 cm in 6 sec	Opaque
		Scrap paper	Circular	90	Well formed	0.5 cm in 6 sec	Opaque
		Coloured paper	Circular	83	Thick spots	1.2 cm in 6 sec	Opaque
		Paper + Bagasse	Circular	94	Thick spots	0.9cm in 4 sec	Opaque
		Paper + Cotton	Circular	78	Thick spots	2 cm in 6 sec	Opaque
		Paper + Coir waste	Circular	120	Well formed	2.1 cm in 4 sec	Opaque
		Paper + Jute waste	Circular	100	Well formed	2.2 cm in 2 sec	Opaque
Paper from other fibres	Mechanical Method	Paper + Rags	Circular	89	Thick spots	1.0 cm in 2 sec	Opaque
		Paper + Saw dust	Circular	63	Well formed	0.8 cm in 1 sec	Opaque
		Paper +Banana	Circular	97	Thick spots	2.1 cm in3 sec	Opaque
		Paper +Jute + Rags	Circular	87	Thick spots	2.4 cm in 5 sec	Opaque
		Paper + Jute +Banana	Circular	78	Thick spots	0.8 cm in 3sec	Opaque
		Banana	Circular	86	Well formed	2.3 cm in 4 sec	Opaque
		Paper + Banana	Rectangle	150	Thick spots	1.0 cm in 2 sec	Opaque
		Post consumer paper	Chart	150	Well formed	0.9 cm in 3 sec	Opaque
			Paper	90	Thin spots	1 cm in 3 sec	Opaque

Table 5. Details on Paper Crete Hollow blocks

S. No	Quantum of paper pulp used (gms)	Size of blocks l*b (cm)	Thickness (cm)	Weight (kg)	Load (kn)	Surface area (cm <sup>2</sup> )	Compressive strength (kn/cm <sup>2</sup> )	Percent increase (%)
1	Original sample (without paper pulp)	38*14	14	18.5	65	532	0.12218	-
2	250	38*14	14	19	87	532	0.16353	25.2
3	500	38*14	14	19.5	116	532	0.218045	43.9
4	750	38*14	14	20.5	150	532	0.281954	56.5

range is probably much wider. Also considering that the product is created from a secondary crop it is a double win situation in that it is using the waste product from one industry (which is either discarded or burned) to produce product for another. Having come to know that the extent of biomass left into the waste stream and the knowledge that, they can be successfully pulped motivated this venture. Table 3 gives details on other fibres used in different permutation combination with paper waste for making paper. As agro waste cannot be used to produce paper, they were added only as additives to paper waste to produce paper. The experiments done proved that it is possible to make paper with cooked banana stem without adding paper, but is not possible with other wastes. So other wastes like cotton, bagasse, coir waste, saw dust, rags and jute waste were mixed with paper in different permutation combinations. As another option banana stem was soaked in NaOH overnight to soften the stem fiber. This did not necessitate cooking the banana stem before grinding. The experiments proved that without using financial commitment handmade paper can be successfully produced in domestic conditions too.

#### 4. Satisfaction of Paper - Specific Characteristics

In the higher order of quality assessment, paper has to qualify for certain characteristics as per set norms. The details of the status of the handmade paper produced under experimental study are presented under Table 4. The tests conducted proved that the paper made by both the techniques were of good quality. The personnel from the testing center adjudged that the papers were fool proof and could be used like any other mill made paper.

#### 5. Value Addition of Recycled Paper

Recycled paper or pulp from any source can be put to any use as virgin paper or paper from mills. To motivate production among public and to enhance its use and sale, such handmade paper or pulp has to be converted into value added products. The efforts to enhance the recovered paper for commercial as well as industrial uses were:

##### a) Change in Physical Appearance of the Paper

As the paper made by recycling was not much appealing, additives (eco friendly) were incorporated in the pulp. In the conventional method, turmeric powder, cinnamon, starch, glycerin, pomegranate (rind, cooked and mashed), tea dust (as brew), ground henna, ground red hibiscus (single petal), myrobalan and ground beetroot were used. For textural effects other agro wastes in different permutation combinations were added.

##### b) Conversion into Consumer Goods

Consumers are on the lookout for materials which are novel and which can satisfy their multiple needs. The investigator

was able to utilize it for making many products which can be of use in institutions, households, recreational items, decorative pieces and educational purposes and the like. It is concluded that the paper made by both techniques lend themselves for folding, tearing, writing etc, that is, to all stresses to which any paper would be subjected to. Hence, it is recommended that handmade paper surely can be attempted by anybody, be it as a domestic venture, cottage industry or a small scale unit.

#### c) Production of Paper Crete Hollow Block (Industrial use)

Hollow blocks are made using the components of cement, rock dust and jalli (small stone). Addition of paper pulp with the same components of the blocks were tried and tested (Table 5). The study revealed that the addition of post consumer paper pulp with the components of the hollow block effectively helped to increase the weight, load, surface area and compressive strength of the hollow block. The study thus proved recycled paper pulp to be feasible for both commercial and industrial uses like paper and hollow block making. It can be an entrepreneurial avenue for men folk too in a suburban/rural setting as these hollow blocks making units are generally located there.

#### Conclusion

Economics is concerned with looking at the cost and benefits of flow of a resource from the natural environment to its final disposal. In its classical form, it suggests that unless at every stage in the process the benefits exceed the cost and therefore somebody makes a profit, the resource will not be developed. A resource then becomes 'uneconomic'. By resorting to making recycled paper at user-centric regions and recovering the wasted resources, these goals can be achieved easily and make resource use really 'economic'.

We may have greatly modified nature,  
We have by no means been able to replace it.  
Let us pledge to replace it.

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