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RESEARCH ARTICLE

A Feasibility Inquiry to the Sustainable Utilization of Few Invasive Flora

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Abstract

Objectives: The study focuses on utilising invasive flora affecting the indigenous plants and thereby bring about monetary benefits to the local people by means of handmade papers from the invasive weeds. **Methods:** Handmade paper from five invasive plants namely, *Eichhornia crassipes*, *Eupatorium odorata, Combretum indicum, Lantana camara* and *Hyptis capitata* was attempted. These plants after collection from Nilambur, Kerala were subjected to treatment with washing soda, blending, vat preparation, moulding and drying. This is followed by checking the paper quality parameters viz., Productivity, Clarity/opacity/transparency, Strength, Grammage, Paper grain, Ageing of paper and Moisture content. **Findings:** Out of the five invasive plants tested, the fibre yield was maximum for *Eichhornia*, but the productivity rate was less compared to other samples. *Lantana* and *Hyptis* yielded maximum productivity even though the fibre yield from these plants was less. The fibre uniformity of paper developed was positively detected for all the 4 plants except *Eichhornia* thereby proving the feasibility for paper manufacture. All sample paper allows the light; so, all are translucent in nature. Integrity of paper samples was retained in the paint test. The age test also yielded positive results. The gsm test showed lowest for *Eichhornia* as 98.12g/m^2; *Lantana* 111.87g/m^2; *Combretum* 131.87g/m^2; *Hyptis* 163.75g/m^2; *Eupatorium* is 255g/m^2. Even though the gsm of *Eichhornia* is the best for paper manufacture according to gsm standards, the lack of fibre uniformity is a withdrawing feature for feasibility. The moisture content appeared high for *Eichhornia* and lowest for *Combretum*. **Novelty:** To date, studies on invasive plant utilisation done individually; no comparative study on productivity done. Current study can be further refined for environmental sustenance along with livelihood for local people.

Keywords: Invasive Flora; Paper manufacture; Grammage test; Productivity; Ecological sustainability

1 Introduction

Floral invasions have been commercially utilised by humans, but which was later found to be detrimental to local biological systems. The exotic flora gains momentum in

different parts of world due to their high adaptability, rapid reproduction rate, different modes of propagation and resistance to biotic and abiotic stress conditions. These alien floral invasions have high impact on biodiversity of plants that has to be seriously addressed. Complete extinction of native species due to competitive exclusion, niche relocation or hybridization with related species can occur leading to genetic contamination. The spread of invasive species causes ecosystem degradation and fragmentation. These processes are identified as the world's greatest threats to nature and key causes of species extinction [1].

An innovative approach to utilise the alien flora for developing handmade paper as an elusive technique of the plant elimination from invaded areas was attempted. Also, it can be developed into a sustainable livelihood of local people engaging them, providing monetary benefit.

Taking these factors to consideration, an analysis on the expediency of five invasive plants namely *Eichhornia crassipes, Eupatorium odoratum, Combretum indicum, Lantana camara* and *Hyptis capitata* for paper manufacture was carried out and the quality of paper developed was tested.

Eichhornia crassipes, of family Pontederiaceae is an aquatic plant native to the Amazon basin [2], but completely acclimatized to wherever it is introduced with its luxurious growth creating greater menace to aquatic ecosystems, clogging waterways, and leading to eutrophication. *Eupatorium odorata*, a tropical and subtropical species of flowering shrub of family Asteraceae, is native to the America and has been introduced to other parts. The highly adapted mechanism of pollination, dispersal methods, allelopathic effect on other plants has led the plant to be described as worst weed invader [3]. *Combretum indicum* is a common plant visible on the railway track premises of India and reported as high risk weed species by many of the European countries. The plantlets form thick flushing clusters along with parent plant and prevents growth of all nearby plants. *Lantana camara*, belonging to the verbena family (Verbenaceae), native to the American tropics, can out compete native species, leading to a reduction in biodiversity and causing problems like toxicity to livestock and reducing the productivity of farmland. The plant has invaded vast tracts of moist-forests and other cultural waste lands in India [4].The plant *Hyptis capitata*, shrub of family Lamiaceae native to Europe but naturalized in other areas is reported to dominate or replace the natural shrub/herb layer of more open plant communities and is reported as invasive plant that dominate over and subdue the growth of native plant species [5]. These plants were used, and paper was synthesised and tested for quality parameters.

Eichhornia crassipes has been investigated for multipurpose applications like bioenergy, biofertilizer, animal feed, wastewater treatment, biocompost and handmade paper [6]; *Eupatorim odorata* in biogas production in earlier studies and other species of this plant has been focused for cosmetic purpose for its active compounds [7]. The plant *Combretum indicum* has been studied for its phytochemical and antimicrobial properties [8]. Studies on the use of *Lantana* as fertilizer, energy, fuel wood was conducted earlier [4]. The medicinal properties, larvicidal effects [9] of *Hyptis capitata* has been studied. No comparative study of paper production capacity of these plants is undertaken. Therefore, the present study gains ecological significance.

2 Methodology

The paper manufacture from the plants and its quality parameters are done in several steps. The preliminary step of the work was paper manufacture. The plants were collected from Nilambur forest area premises and the road tracks nearby at their flowering stage.

- **Paper manufacture**

For this study, 1.5 kg stem and leaves were taken from the *Eupatorium odorata* and *Combretum indicum* and from the *Lantana camara* and *Hyptis capitata* only the stem were taken and in the case of *Eichhornia crassipes* the petioles were used for making paper. The plants used for study are shown in Figure 1. The parts of the collected samples were boiled with washing soda and washed well and grinded nicely to form the fine fibres. The blending was done till the fibres were clearly separable from the blending mix. The fully separated fibres were used for further analysis. Since it is a feasibility analysis, measurement of fibre thread size has little relevance and hence not done. Then vat was prepared and put the fibres into it and by using deckle and mould the sample was collected from the vat and dried.

- **Sizing**

This was checked by bleeding property on applying ink test.

- **Strength**

Depending on paper application different testing methods are used to determine its strength, such as breaking strength, tensile strength, breaking length, elongation, tearing strength, folding resistance, and stiffness. Here folding test was conducted.

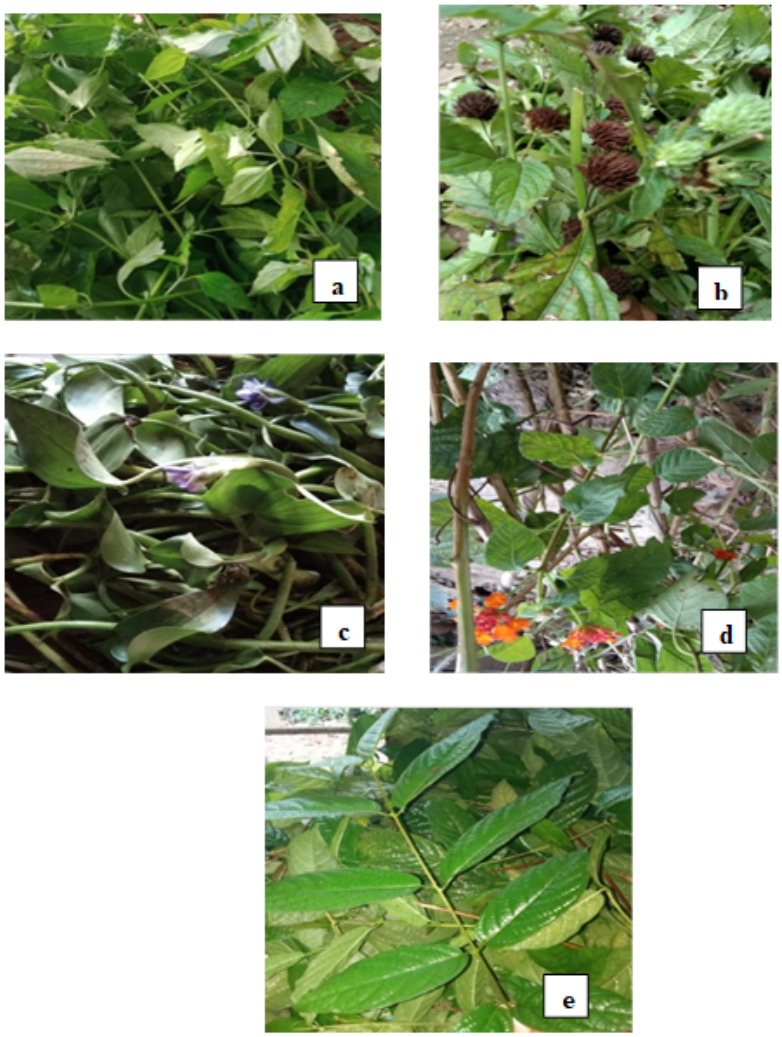

Fig 1. Photographs of the *Eupatorium odoratum* (a), *Hyptis capitata* (b), *Eichhornia crassipes* (c), *Lantana camara* (d), *Combretum indicum* (e)

- **Grammage & Thickness**

Grammage is defined as the weight per square meter and expressed in gsm. Grammages of up to 200 gsm are considered to be papers and from 200 gsm upwards they are referred to as paperboard or low-quality board. For this standard, the weight of various types of paper is measured from a sample cut to one square meter in size.

- **Paper grain**

The grain can be easily tested in practice by tearing the paper on the long and on the short side. If the paper tears relatively cleanly and in a straight line, it means it is torn in the machine direction. If the line is ragged and irregular, the paper has torn in the cross direction.

- **Ageing of Paper**

Resistance to ageing depends primarily on the quality of raw materials. This stealthy process is caused by aluminium sulfate, which is added to fibres in order to precipitate resin size. The paper was placed in sunlight for 2 weeks to test colour change.

- **Moisture Content**

Oven Dry method was used. Paper sample weighed and then exposed to a 221°F in the oven. When the samples are re-weighed after cooling the gravitational difference is calculated as "Percent Moisture".

3 Results and Discussion

From *Eichhornia crassipes*, 3 sheets of paper were made by using 1.5 kg of *Eichhornia* sample, out of which 1.4 kg of stripped fibre obtained. The second sample, *Eupatorium odoratum*, harder than *Eichhornia* yielded 4 sheets of paper from 1.5 kg of fibre out of which 1 kg of stripped fibre obtained. The third sample, *Lantana camara* yielded 5 sheets of papers out of 1 kg of fibre from which 0.75 kg of stripped fibre was obtained. The fourth sample was *Combretum indicum*, and it yielded 4 sheets of paper from 1.5 kg of fibre which yielded 1 kg of stripped fibre. The fifth sample was *Hyptis* and yielded 5 sheets of paper from1 kg of fibre that produced 0.8kg of stripped fibre. The paper is the first of its kind and so the comparative yield report of plants studied here are not available. A bleaching protocol of the handmade paper of *Eichhornia crassipes*[6] and paper pulp production by sulphate process in *Lantana camara*[4] was reported. The GSM, thickness, and strength of paper production from different parts of water hyacinth was studied[10]. The yield results of these plants, therefore, is not comparable. But literary works confirms the possibility of handmade paper and craft paper from *Eichhornia crassipes* and *Lantana camara*.

- **Fibre Yield**

The fibre yield of plant can be calculated by subtracting the weight of the useful fibre from that of the stripped inner bark. The fibre yield percentage was highest for *Eichhornia* (93%), *Eupatorium* (67%), *Lantana* (75%), *Combretum* (67%) and *Hyptis* (80%). The data shows a higher fibre yield for *Eichhornia* followed by *Hyptis*. Consequently, the fibre waste was calculated by subtracting the fibre yield percentage from the total weight percentage of each sample (100%). The wastage of fibre was least in *Eichhornia*. The plants *Eupatorium odorata* and *Combretum indicum* showed the highest fibre wastage.

- **Productivity Level**

The productivity of sheets was highest for *Lantana* followed by *Hyptis*. The productivity level graph is shown Figure 2. The productivity level was low for *Eichhornia*. Even though, fibre wastage was less in *Eichhornia*, since the fibres were much delicate, they break off more easily. This produced a less effective pulp and therefore decreased productivity levels and output. The productivity levels reflected the number of sheets produced as well as the fact that, although some species like *Eichhornia* had a high fibre yield, this did not necessarily mean they were productive. This fact is important when producing paper in large quantities. Since lignin and cellulose are present in the fibre of *Eichhornia*, the paper production was successful in study[10], and they discovered root and petiole shows higher strength in the plant. The fibre production in *Eichhornia* in the present study is supported by this work.

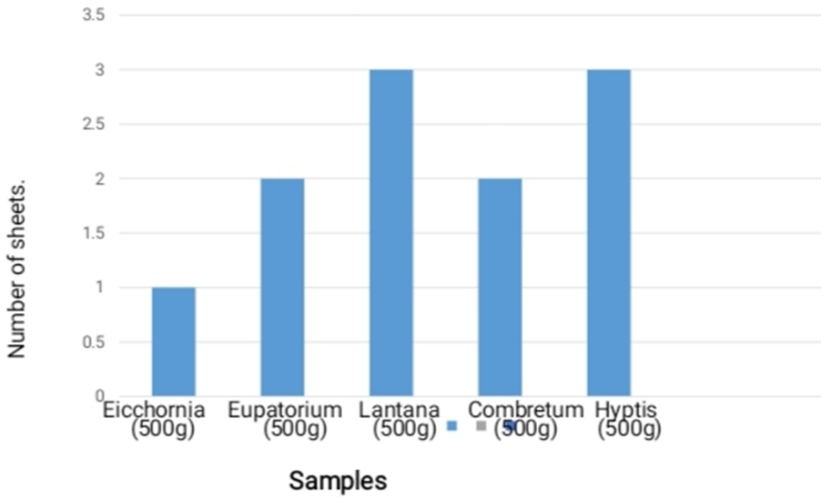

Fig 2. Productivity level graph of five samples

- **Grammage Test**

The grammage or 'basis weight' of paper, board and tissue is determined by weighing a known area after conditioning in a standard 23°C, 50% RH environment for a minimum of 24 hours. Results are usually quoted as gsm or g/m^2. It is done to determine the weight and thickness of the paper.

Formula:

$$Grammage = \frac{10000 \times mass\ (in\ gms)}{Length\ (cm) \times Width\ (cm)}$$

GSM is one of the most important values for many different materials such as paper, packaging sheets and others. The GSM is the measure of weight of a material per square meter area of that material. So, this is one of the most important aspects while analysing the quality of paper.

In this study, GSM of paper made from selected five different invasive species were calculated. As per the result, GSM of first sample *Eupatorium* is 255g/m^2; GSM of second sample *Combretum* is 131.87g/m^2; GSM of third sample *Hyptis* is 163.75g/m^2; GSM of fourth sample *Lantana* is 111.87g/m^2; GSM of fifth sample *Eichhornia* is 98.12g/m^2. From the result it is identified that GSM value of *Eupatorium* is high and that is 255g/m^2 and GSM value of *Eichhornia* is low and that is 98.12g/m^2. So, the paper with a weight of 98.12g/m^2 is much lighter and thinner than the other papers and the 255g/m^2 GSM paper will be heavy, thick, and much more durable. Grammage determines the category the material falls into: paper, material with a grammage below 160 g/m^2; paperboard, with a grammage between 160 g/m^2 and 500 g/m^2; and cardboard, with grammage over 500g/m^2 [10]. This also makes it identifiable that Eichhornia paper sheets can be used for thin paper as well as the sheets of Eupatorium can be used as paper board. The study [10] shows lower GSM for petiole of *Eichhornia crassipes* which is in conformity and the study [10] recommends the suitability of *Eichhornia crassipes* petiole suitable for the paper making process.

- **Moisture Content**

The moisture content of paper and paperboard is the quantity of water present and measurable in paper. This will vary according to the environment and the moisture added during manufacturing and conversion processes.

$$Moisture\ Content = \frac{Initial\ weight - oven\ dry\ weight}{Oven\ dry\ weight} \times 100$$

The moisture content of *Eupatorium* was 6.5%; *Combretum* was 4.9%; *Eichhornia* was 7.5%; *Hyptis* was 6%; *Lantana* was 5.9%. This determines the suitability of the product being used as paper/paper board/cardboard. No such comparative reports of the above plants are available till date. The moisture content of *Eichhornia* is found to be highest in the present work and lowest for *Combretum*. The content of *Hyptis* and *Lantana* are comparatively similar. The higher moisture content is not suitable for packaging and so the test shows *Eichhornia* as unsuitable in comparison with other test materials. The moisture content of samples is presented in Table 1.

Table 1. Moisture Content in the developed papers

Sl No	Name of the plant material	Weight of paper sample before oven drying (initial weight)	Weight of paper sample after oven drying
1	*Eupatorium odoratum*	0.408	0.383
2	*Combretum indicum*	0.211	0.201
3	*Eicchornia crassipes*	0.157	0.146
4	*Hyptis capitata*	0.262	0.247
5	*Lantana camara*	0.179	0.169

- **Qualitative tests**

The ink test, translucent test, folding test, paint test and age test were done for the qualitative analysis of paper. In the ink test, no bleeding was observed in papers except *Eichhornia*. The results are summarised in Table 2. In the translucent test, all the samples allowed the passage of light. In the paint test, all the sample papers retained its integrity. In the age test, all the papers maintained its texture and it doesn't pale its colour or it doesn't become brittle. The ink test revealed that except in *Eichhornia*, all other samples did not bleed, showing the uniformity of fibre alignment. In the folding test, different result was obtained and

Eichhornia, *Lantana*, and *Hyptis* were folded with crisp sharp creases but the *Eupatorium* and *Combretum* folded but not with a crisp sharp crease, which throws light on the hardness of the paper made. All the tests were conducted in a very simplistic manner, but the outcomes were very interesting in terms of the various properties and characteristics of the paper. No sizing or additives for strength were added to the pulp in any of the samples. It must be noted that this investigation was set out to determine whether these particular species could, in fact form a sheet of hand-made paper and the comparative output of each was analysed. The papers were not meant for a specialized market but rather for the craft sector. Further research could be undertaken especially for the more successful species like *Hyptis capitata* and *Lantana camara* which has shown moderate levels of test results in this research.

Table 2. Summarisation of Qualitative tests conducted

Samples	Ink Test	Folding Test	Translucent Test	Paint Test	Age Test
Eicchornia	It bleeds	Folded with crisp sharp	Allows light	Paper retains its integrity	No change in texture of paper
Eupatorium	Not bleeds	Folded but not crisp sharp	Allows light	Paper retains its integrity	No change in texture of paper
Lantana	Not bleeds	Folded with crisp sharp	Allows light	Paper retains its integrity	No change in texture of paper
Hyptis	Not bleeds	Folded with crisp sharp	Allows light	Paper retains its integrity	No change in texture of paper
Combretum	Not bleeds	Folded but not crisp sharp	Allows light	Paper retains its integrity	No change in texture of paper

4 Conclusion

The analysis detected higher fibre yield in *Eichhornia*, but with less productivity. The number of hand- made papers developed in this case was less. In the case of *Lantana* and *Hyptis*, fibre yield is much less in comparison with *Eichhornia*, but the productivity is high, and this makes them feasible for large scale paper production. In this study, except washing soda, no other chemicals or additives was added for improving the quality of paper, thereby ascertaining the eco-friendliness of the method.

This study can serve as a "start-up" for making craft papers as well as hand-made papers from invasive plants. From this study, two benefits are accomplished - the study focuses on monetary benefits that can be made by local people with handmade paper and additionally, the removal of invasive plants can be envisaged as a positive move for environment sustenance, maintaining the survival of local floral biodiversity.

The methods utilised in the study can be more rarefied for practical utility as use of sophisticated instruments can ease the job, but with clear and well-defined environment-friendly refinements.

To date, no similar work has been reported on a similar scale, so results that include the feasibility of invasive plant utilisation particularly *Hyptis* and *Lantana* forms a basis for the future developmental strategies in this accord. Further work must be promoted to improve and prove to what depth these plants can be used for commercialized paper manufacture, either for craft paper or more refined writing papers to increase the solidity of data obtained by this work.

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