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Evaluation of Parthenium for pulp and paper making

Sanajy Naithani, R.B. Chhetri[1], P.K. Pande and Geetika Naithani
Forest Research Institute P.O New Forest, Dehra Dun (Uttarakhand)
[1]ABC Paper Mill Sailakhurd (Punjab)
E-mail : pandep@icfre.org

ABSTRACT

***Parthenium hysterophorus,* a weed commonly known in India as congress grass was evaluated for its pulp and paper making properties. Studies on chemical constituents, fibre dimensions, unbleached, bleached yield and physical strength properties of pulp sheets were carried out. The proximate analysis of *Parthenium hysterophorus* showed that its plant material contained 78.0% holocellulose and 17.2% lignin. The pentosan was 15.8% and solubility in hot water and alcohol benzene was 11.25% and 5.89%. The unbleached pulp yield was 41.8% to 43.8% with varying alkali charge from 14-16% in soda cook. Kappa number was 27.2 to 30.2. Pulping pulp yield and kappa number decreased with the increase in alkali charge under the identical conditions. The pulp produced using 14% alkali charge had better strength properties as compare to pulp produced using 15% and 16% alkali charge. Laboratory handmade pulp sheets with adequate strength properties were obtained from soda pulp prepared from this plant material.**

Key words: *Parthenium hysterophorus*, Kappa number, Pulping, Bleaching

The conventional raw materials like softwood, hardwood and bamboo used for pulp, paper and cellulose based industries are depleting day by day. It is predicted that by the turn of the 2020, there will be a global shortage of these raw materials. During the last three decades, though, many of the forest based fast growing annual and perennial plants have been identified, cultivated and their suitability for pulp and paper making have been studied (Cunningham *et al*. 1970, Zarges *et al*. 1980, Saikia *et al.* 1990 a and b, Ali *et al.* 1993, Sarma and Goswami 1993, Sarma *et al*. 1996, Nelson *et al.* 1996, Ali and sakia 1997, Rox and Luiz 1998, Rai *et al.* 2000, Mukherjee 2003, Singh *et al*. 2003). Search for new fiber crops has been underway and is continuing. There is a necessity to evaluate new fiber crops which may be available on the sustainable basis.

Parthenium hysterophorus is widely distributed as a noxious weed in waste lands, degraded soil, rock crevices, along water canal, bunds, road sides, railway tracks, coalfield areas and recently invaded in cropped areas. The management of this weed is a great problem and different management methods like mechanical, legal, biological (Jaykumar *et al*. 1984, Mahadevappa and Ramaian 1988, Singh 1993, Patel and Mahadevappa 1997) and chemical (Balyan *et al.* 1997) are approached for its eradication. Satisfactory approach is yet to be found.

The systematic studies is required to optimize process parameters for producing pulp for writing and printing grade paper for this weed so that the problem of its eradication can be solved by utilization. Hence, the objective of the paper is to study the pulp and paper making characteristics of *Parthenium hysterophorus* at laboratory scale.

MATERIALS AND METHODS

Raw material: *Parthenium hysterophorus* biomass was collected from the field. The stem portions of the plant were taken after cleaning and removal of leaves. The stems without debarking were cut into the pieces of 2-2.5 cm length. The chips as prepared were dried to a moisture level 10-12% and then used for experimental work on oven dry weight (O.D.) basis after determining the bulk density.

Proximate chemical analysis: The chips powdered in a Willey mill and portion passed through 40 mesh and retained on 60 mesh was taken for the study. The proximate chemical analysis was carried out as per Tappi Standard Method.

Fiber morphology: Morphological characteristic of the fiber were determined using maceration technique. About 25 fiber cells were measured randomly for their length, diameter, wall thickness and lumen diameter.

Pulping: Soda pulping was carried out in an electrically heated stainless steel digester with thermostat controlled system keeping bath ratio 1:4. The digestions were carried at varying chemical concentration for 4 to 6 hrs including time to raise the temperature $165^0 \pm 2^0$C. The pulp after

digestion was thoroughly washed with water . The unbleached pulp yield, kappa numbers, rejects, *etc.* were determined. The black liquor after each digestion was collected for determination of total solids and residual active alkali.

Bleaching: The unbleached pulps were bleached by C-E -H-H sequence. The strength and optical properties of bleached pulp were evaluated.

Paper sheet formation and testing: The unbleached and bleached pulps were beaten in a laboratory valley beater to 30 ^{O}SR. Sheets of 60± 1gm^{2} were prepared from the pulps in a British standard laboratory hand sheet making machine followed by pressing and drying. The pulp sheets were conditioned at 65% relative humidity at 27^{0}C for 2 hrs and then tested for various physical properties.

RESULTS AND DISCUSSION

The results of proximate chemical analysis are recorded in Table 1. From the results, it is evident that plant material contained 78.0% holocellulose and 17.2% lignin. The pentosan was 15.8% and solubility in hot water and alcohol-benzene was 11.25% and 5.89%. One percent NaOH solubility is important in assessing the soundness of wood in respect to its decay. The value ranging from 10-30% is normally considered adequate for further investigation. The 1% NaOH solubility was 22.5% which exhibit it as suitable raw material for pulp and paper.

Table 1. Proximate analysis of *Parthenium hysterophorus*

S.No.	Parameters	Percentage
1	Hot water solubility, %	11.25
2	1% NaOH solubility, %	22.5
3	Alcohol–Benzene solubility, %	5.89
4	Holocellulose, %	78.00
5	Alpha Cellulose, %	65.00
6	Pentosan, %	15.8
7	Lignin, %	17.2

The morphological characteristics of *Parthenium hysterophorus* are given in Table 2. The morphology of fiber plays a very important role on the structure and properties of paper. The fiber length affects the sheet formation or uniformity of fiber distribution, the shorter the fibers, the closer and more uniform will be the sheet formation.

Table 2. Morphological characteristics of *Parthenium hysterophorus*

Parameters (µ)	Whole stem	Central portion	Central free portion	Central portion & bark free
	Average	Average	Average	Average
Fiber length	554.61± 132.22	965±219	875±179	874±180
Fiber diameter	14.94± 0.55	21±3.8	19±4.2	20±4.3
Lumen diameter	14±3.5	15±3.7	14±3.5	14±3.9
Wall thickness	3±0.7	2.8±0.7	3±0.7	3±1.1

Table 3 (a) shows pulping condition and properties of unbleached pulp of soda pulping. The unbleached pulp yield was 41.8% to 43.8% with varying alkali charge from 14-16% in soda cook, Kappa number was 27.2 to 30.2. It was observed that under the identical conditions of pulping pulp yield and kappa number decreased with increase in alkali charge.

The physical strength properties of unbleached pulps are recorded in Table 3 (b). It may be seen that the pulp produced using 14% alkali charge with better strength properties as compare to pulp produced using 15% and 16% alkali charge.

Table 3(a). Pulping conditions, pulp yield and Kappa No. of *Parthenium hysterophorus* Soda pulps.

O.D. raw material (gm)	500	500	500
Alkali charge (%)	14	15	16
Pulp aid (%)	0.05	0.05	0.05
Bath ratio	1:4	1:4	1:4
Cooking time (Hrs)	3	3	3
Temperature (^{0}C)	165	165	165
Unbleached yield %	43.8	42.5	41.8
Kappa number	30.2	29.5	27.2
pH	12.21	12.38	12.46
RAA (Gpl)	1.0	1.2	1.8
^{O}TW	9.5	10.2	10.6
Total solid %	10.0	10.7	11.2

Table 3(b). Physical strength properties of unbleached soda pulps of *Parthenium hysterophorus*.

Particulars	14%	15%	16%
^{O}SR	30	30	30
B.Wt (g/m^2)	61.0	60.4	60.0
Breaking length (m)	3810	3700	3680
Tear factor	45.6	44.2	44.0
Burst factor	20.2	19.4	18.2
Bulk (cm^3/g)	2.20	2.17	2.18
Ash%	2.7	2.8	2.7

Table 4 Shows the condition and sequence of bleaching of *Parthenium hysterophorus* pulp. Pulp yield 40.1%, 39.0% and 38.4% for the pulp produced using 14%, 15%, 16% alkali charge at 12% chlorine demand with 76.2%, 77.6% and 78.5% brightness, respectively However, a drop in pulp yield was observed in the case of pulp produced using 15% and 16% alkali charge when compared to 14%.

The physical strength properties of bleached pulps recorded in Table 5. It is observed that breaking length is more in pulp produced with 14% alkali charge as compare

Table 4. Condition and bleaching sequence (C-E_r-H-H) of *Parthenium hysterophorus* pulp

		Chlorination		
	Unit	14%	15%	16%
OD pulp	Gm.	100	100	100
Cl_2 Added	%	7	7	7
pH (initial)	-	2.42	2.37	2.44
Retention time	Min.	45	45	45
pH (final)	Value	2.08	2.10	2.04
R-Cl_2	Gpl	0.00248	0.00142	0.0426
Cl_2 consumed	%	6.99	6.99	6.88
Washed pH	%	4.22	4.26	4.30
Alkali Extraction				
Temprature	0C	60	60	60
Alkali added	%	2.5	2.5	2.5
H_2O_2	Kg/T	8	8	8
pH (initial)	-	10.22	10.87	10.92
Retention time	Hrs	2	2	2
pH (final)	-	9.52	9.65	9.71
Washed pH	-	8.20	8.23	8.29
Kappa number	-	5.4	5.0	4.8
H-I Stage				
Temperature	0C	40	40	40
Hypo added	%	3.5	3.5	3.5
pH (initial)	-	8.10	8.22	8.28
Retention time	Hrs	2	2	2
pH (final)	-	7.54	7.62	7.70
R-Cl_2	Gpl	0.00142	0.00142	0.0071
Cl_2 consumed	%	3.49	3.49	3.49
H-II Stage				
Temperature	0C	40	40	40
Hypo added	%	1.5	1.5	1.5
pH (initial)	-	7.84	7.92	7.96
Retention time	Hrs	2	2	2
pH (final)	-	7.50	7.52	7.58
R-Cl_2	Gpl	Nil	0.00213	0.00142
Cl_2 consumed	%	1.5	1.49	1.49
Total Cl_2 charged	%	12	12	12
Cl_2 consumed	%	11.98	11.97	11.86
Brightness	%	76.2	77.6	78.5
Shrinkage	%	8.4	8.2	8.0
Bleached yield	%	40.1	39.0	38.4

to 15% and 16%, but tear factor dropped slightly. Burst factor is slightly increased in 15% and 16% alkali charge pulp as compare to 14% alkali charge pulp. Bulk and ash content almost same in 14%, 15% and 16% alkali charge pulps. All the pulp possess adequate strength properties and can be used for production of varieties of paper.

Table 5. Strength properties of bleached pulp of *Parthenium hysterophorus*

Particulars	14%	15%	16%
^{o}SR	34	34	34
B.Wt (gm^{2})	61.2	60.7	60.2
Breaking Length (m)	3410	3159	3155
Tear factor	34.5	36.0	38.0
Burst factor	18.4	18.5	18.8
Bulk (cm/g^{-})	2.17	2.18	2.18
Ash%	2.00	2.00	2.10

On the basis of experiment carried out on evaluation of *Parthenium hysterophorus* for pulp and paper making and its conversion into derivatives with properties useful in industrial application thereby utilizing the exploitable potential of the obnoxious weed. This utilization would, therefore, pave the way for effective and safe management of the weed. This would also convey socio-economic and environmental benefits to the country, besides to meet the growing raw material demand in pulp and paper industry.

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