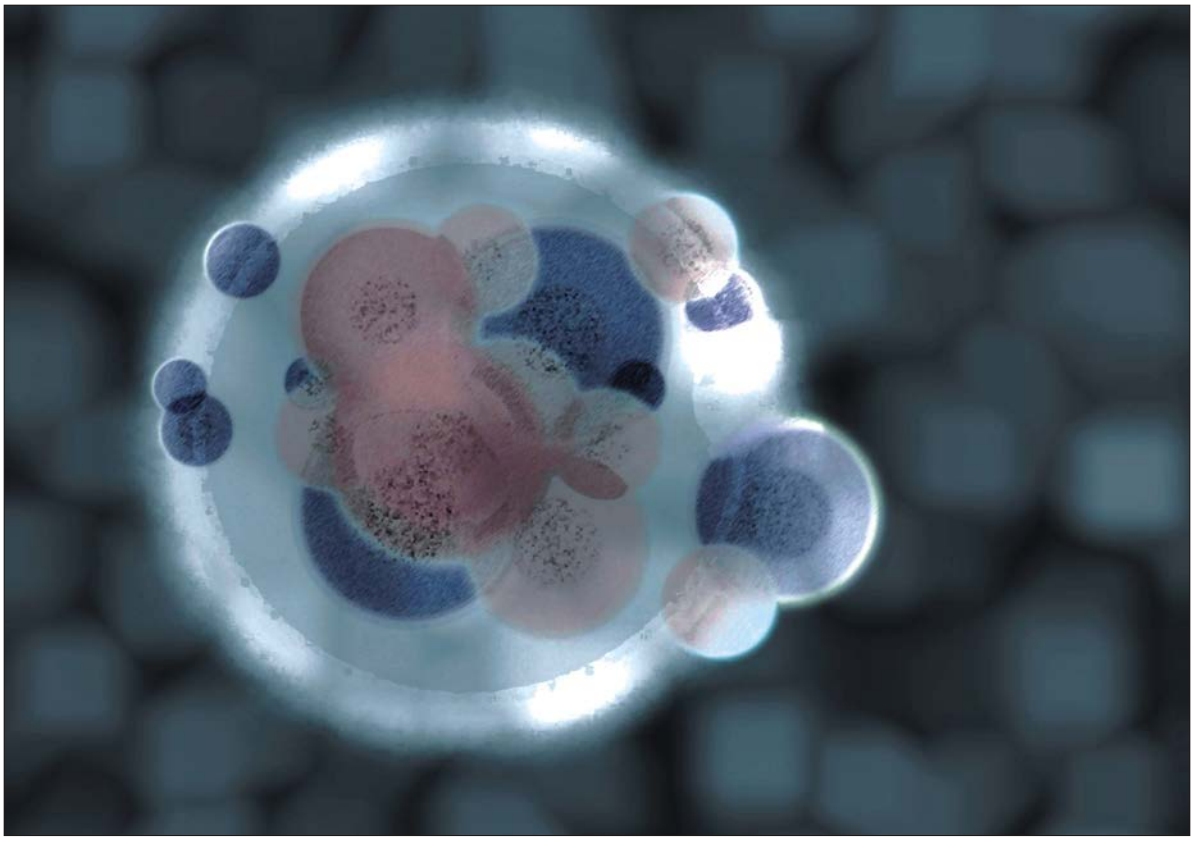

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Studies on Physico-Chemical and Microbiological Parameters of Water Samples Before and After Jute Retting

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Abstract: The aim of the research was to study the effect of jute retting on various physico-chemical and microbiological parameters of retting water and water samples were collected before and after retting, from three well-known jute growing areas of N-24 Parganas viz., Sonatikari, Baduria and Swarupnagar, West Bengal, India. Standard methods were applied to determine pH, Ec, Chemical Oxygen Demand (COD), hardness, Calciuni (Ca), Magnesiuni (Mg), bicarbonate, chloride content, bacterial, fungal, pectinolytic and spore forming bacterial colony forming units. Irrespective of the locations, the pH of the post-retting water samples was more acidic than the pre-retting water samples. Other physico-chemical parameters like Ec, COD, hardness and metal contents increased in the post-retting water samples. The post-retting water samples also registered higher bacterial, fungal, pectinolytic and spore forming bacterial colony forming units.

Key words: Jute, retting water, COD, hardness, metal contents, colony forming units

INTRODUCTION

Jute (*Corchorus* sp.) is a very important fibre and cash crop (Talukder *et al*., 2001; Ali *et al*., 2002). Almost 85% of the world's jute cultivation is concentrated in the Gangetic delta of Bangladesh and India. The total area under jute cultivation in India varies between 6.38 lakh hectares and 10 lakh hectares which is the highest in the world. The districts of Nadia, Murshidabad, Cooch Bihar, West Dinajpur, Jalpaiguri, North 24-Pargana, Hoogly and Malda in West Bengal account for 71% of area under jute cultivation in India and 73.09% of total raw jute production in the country (Roul, 2009). The highest concentration occurs in the Baduria and adjoining region in the north-east of the North-24 Parganas district at present.

Jute fibre is obtained through the process of retting, which is essentially a microbiological and biochemical process (Haque *et al*., 2001a). The jute bundles are steeped in water and subjected to controlled decomposition of biopolymers such as pectins, celluloses, and hemicelluloses that hold the bast cells to the rest of the stem (Haque *et al*., 2001b). Biological retting is the cheapest and a universally practiced method for the commercial extraction of jute fibre (Munshi and Chattoo, 2008).

Retting and fibre extraction problems are complex and multi-disciplinary in nature. Retting does not produce any toxic substances and the materials released during the process are fully biodegradable. However, the quality of water after jute retting becomes degraded transitorily. The microbial load increases excessively and the water become discoloured. Environmental aspect, therefore, should form important component of retting studies. However, there is inadequate data on the subject. A systematic study can therefore be helpful to respond to question on this aspect of retting which is likely to increase due to the growing environment consciousness (Shams-ul-Haque *et al*., 2002).

The quality of jute fibre depends on jute retting processes (Shams-ul-Haque *et al*., 2001) and the availability of suitable water bodies for retting. In water based jute retting, the quality and quantity of microorganisms present in water, several physico-chemical properties of water like pH, hardness and metal contents play important role for obtaining good quality fibre (Adhikary *et al*., 2005). Thus, knowledge and understanding of above parameters of retting water will help in identifying the conditions of retting process and thereby taking measures to improve fibre quality. Furthermore, after retting many of the ponds are also used for pisciculture (Mondal and Kaviraj, 2008). It is, therefore, necessary to determine the quality of the post-retting water and the contamination caused by retting. But very few reports are available in this respect.

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This study was conducted with the objective to assess the water quality, as determined by several physico-chemical and microbiological parameters, during the retting process of jute.

MATERIALS AND METHODS

Sample collection: The jute retting water samples were collected in the year 2007 from three widely cultivated jute growing areas of N-24 Parganas, viz. Sonatikari (22° 41'27"N, 88° 35'44"E), Baduria (22° 44' 24" N, 88° 47' 24" E) and Swarupnagar (22° 49' 59.88" N, 88° 52' 0.12" E) (http://en.wikipedia.org/wiki/) before and after jute retting. In each location water samples were collected from six randomly selected ponds. For each pond three replicated water samples were collected at evenly spaced locations and at close proximity to the submerged mat of jute bundles during retting. The samples were then immediately placed on ice for transport to the laboratory, and preserved at 4°C. The temperature of the retting ponds during the time when water samples were collected ranged from 32-34°C. Microbiological analyses were carried out within 3 to 4 days.

Analytical procedures: The pH of the water samples was determined with the help of Systronics pH meter (Model No. LI120) and Ec of the water samples was measured with the help of Elico Conductivity meter (Model No. CM180). The COD (Pitwell, 1983), total hardness, Ca^{+2}, Mg^{+2}, bicarbonate and chloride contents (Singh *et al*., 1999) of the water samples were determined. Enumeration of bacterial, fungal and pectinolytic microbial populations of water samples was done by the dilution plate technique using Luria agar (Himedia) for bacteria, Rose Bengal agar base (Himedia) for fungi and yeast extract-pectate medium (yeast extract 1%, pectin 1%, NaCl 0.5%, pH 7.0) for pectinolytic microorgamisms. The spore forming bacterial count (Black, 1965) was determined in 0.01% peptone agar medium.

Statistical analysis: Statistical analyses were performed using SPSS 11.0 for Windows (SPSS Inc., USA). The data were analyzed as a single factor ANOVA in a completely randomized block design Comparison of means was done using Duncan's Multiple Range Test (DMRT) at 5% probability level of statistical significance.

RESULTS

The pH of the water samples varied from 7.05 to 7.20, 7.08 to 7.38 and 7.18 to 7.36 at pre-retting period in Sonatikari, Baduria and Swarupnagar, respectively. The same values for post-retting period varied from 5.95 to 6.60, 6.63 to 6.95 and 6.15 to 6.94 in Sonatikari, Baduria and Swarupnagar, respectively (Table 1). At the post-retting stage the water samples from Baduria recorded the highest mean pH (6.80) and the lowest in Sonatikari (6.39). The Ec of the pond waters varied from 0.159 to 0.303, 0.156 to 0.223 and 0.161 to 0.251 dS m^{-1} at pre-retting and 0.501 to 0.993, 0.421 to 1.146 and 0.523 to 1.023 dS m^{-1} at post-retting period in Sonatikari, Baduria and Swarupnagar, respectively with statistical differences between the ponds (Table 1). The mean Ec values of the pre-retting water samples increased at the post-retting period from 0.23 to 0.76 dS m^{-1} in Sonatikari, 0.19 to 0.68 dS m^{-1} in Baduria and 0.21 to 0.70 dS m^{-1} in Swarupnagar. Irrespective of the sites, the COD of the pond waters varied between 35 and 45 mg L^{-1} at the pre-retting period. At the post-retting period the highest mean COD was observed in Sonatikari (218 mg L^{-1}, range 204 to 224 mg L^{-1}) and lowest was in Baduria (194 mg L^{-1}, range 163 to 221 mg L^{-1}). The COD of post-retting water samples from Swarupnagar ranged between 185 and 234 mg L^{-1} with a mean value of 211 mg L^{-1} (Table 1). The hardness of the water samples varied from 64 to 82 (mean 74 ppm), 72 to 88 (mean 80 ppm) and 68 to 80 ppm (mean 74 ppm) at the pre-retting period and 130 to 310 (mean 233 ppm), 112 to 272 (mean 200 ppm) and 138 to 262 ppm (mean 216 ppm) at the post-retting period in Sonatikari, Baduria and Swarupnagar, respectively (Table 1).

The Ca, Mg, bicarbonate and chloride contents of pre and post-retting water samples from Sonatikari, Baduria and Swarupnagar did not vary significantly (Table 2). All of these parameters increased at the post-retting period. Swarupnagar recorded the highest mean Ca content (69 ppm, range 62 to 74 ppm) and the lowest in Baduria (60 ppm, range 43 to 69 ppm) at the post-retting period. The mean Mg content of the pre-retting waters increased at the post-retting stage from 8 to 16, 8 to 23 and 8 to 23 ppm in Sonatikari, Baduria and Swarupnagar, respectively (Table 2). Regarding the bicarbonate content, Sonatikari recorded the highest mean value (7.77 me L^{-1}, range 6.6 to 9.4 me L^{-1}) and the lowest in Baduria (mean 6.87 me L^{-1}, range 4.8 to 8.8 me L^{-1}) at the post-retting stage. The chloride content of the post-retting water samples varied from 5.2 to 8.0 (mean 6.8 me L^{-1}), 4.0 to 5.6 (mean 5.13 me L^{-1}) and 5.2 to 6.8 me L^{-1} (mean 5.8 me L^{-1}) in Sonatikari, Baduria and Swarupnagar, respectively (Table 2).

The bacterial log cfu of pre-retting water samples varied from 4.22 to 4.35 (mean 4.29) in Sonatikari, 4.20 to 4.55 (mean 4.35) in Baduria and 4.29 to 4.47 (mean 4.38) in Swarupnagar (Table 3). The highest mean bacterial cfu at the post-retting period could be detected in Sonatikari (6.65, range 6.22 to 6.93) and the lowest in Swarupnagar (6.37, range 6.20 to 6.57). The bacterial cfu of post-retting

Table 1: Physico-chemical parameters of jute retting water samples

	pH		Ec (dS m^{-1})		COD (mg L^{-1})		Hardness (ppm)	
Village	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Sonatikari								
SP1	7.11^{cd}	6.42^{bc}	0.297^{a}	0.969^{b}	40^{ab}	220^{a}	82^{a}	274^{b}
SP2	7.08^{de}	6.46^{c}	0.303^{a}	0.805^{c}	38^{b}	224^{a}	75^{ab}	276^{b}
SP3	7.16^{b}	6.38^{d}	0.159^{e}	0.797^{c}	45^{a}	220^{a}	64^{c}	262^{c}
SP4	7.20^{a}	6.55^{b}	0.225^{b}	0.501^{e}	42^{ab}	216^{ab}	70^{bc}	146^{d}
SP5	7.05^{e}	6.60^{a}	0.189^{d}	0.522^{d}	39^{ab}	224^{a}	74^{ab}	130^{e}
SP6	7.12^{c}	5.95^{e}	0.21^{c}	0.993^{a}	41^{ab}	204^{b}	78^{ab}	310^{a}
Mean	7.12^{c}	6.39^{b}	0.23^{a}	0.76^{a}	41^{a}	218^{a}	74^{b}	233^{a}
Baduria								
BP1	7.38^{a}	6.95^{a}	0.189^{e}	1.146^{a}	45^{a}	221^{a}	88^{a}	272^{a}
BP2	7.22^{bc}	6.66^{cd}	0.223^{a}	0.734^{b}	42^{ab}	163^{d}	72^{c}	254^{b}
BP3	7.26^{b}	6.63^{d}	0.176^{d}	0.602^{d}	35^{b}	185^{c}	84^{ab}	194^{d}
BP4	7.11^{d}	6.88^{ab}	0.192^{c}	0.456^{e}	40^{ab}	203^{b}	77^{bc}	138^{e}
BP5	7.08^{d}	6.92^{a}	0.156^{e}	0.421^{f}	38^{ab}	194^{bc}	78^{bc}	112^{f}
BP6	7.15^{cd}	6.77^{bc}	0.212^{b}	0.706^{c}	44^{a}	200^{b}	82^{ab}	228^{c}
Mean	7.20^{b}	6.80^{b}	0.19^{b}	0.68^{a}	41^{a}	194^{b}	80^{a}	200^{a}
Swarupnagar								
SNP1	7.36^{a}	6.94^{a}	0.161^{d}	0.523^{e}	42^{ab}	218^{b}	74^{bc}	138^{d}
SNP2	7.20^{cd}	6.78^{b}	0.23^{b}	0.563^{d}	38^{b}	222^{ab}	78^{ab}	190^{c}
SNP3	7.26^{bc}	6.89^{ab}	0.163^{d}	0.647^{c}	40^{ab}	185^{d}	70^{c}	238^{b}
SNP4	7.18^{d}	6.78^{b}	0.247^{a}	0.651^{c}	45^{a}	198^{cd}	68^{c}	240^{b}
SNP5	7.31^{ab}	6.15^{d}	0.251^{a}	0.793^{b}	39^{ab}	234^{a}	80^{a}	262^{a}
SNP6	7.30^{ab}	6.44^{c}	0.193^{c}	1.023^{a}	44^{ab}	208^{bc}	72^{c}	229^{b}
Mean	7.27^{a}	6.66^{b}	0.21^{ab}	0.70^{a}	41^{a}	211^{a}	74^{b}	216^{a}

Value represented by the same superscripts in a column are statistically similar at 5% probability level by DMRT

Table 2: Calcium, magnesium, bicarbonate and chloride contents of jute retting water samples

	Ca (ppm)		Mg (ppm)		Bicarbonate (me L^{-1})		Chloride (me L^{-1})	
Village	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Sonatikari								
SP1	19^{ab}	65^{b}	10^{a}	13^{b}	2.6^{bc}	9.4^{a}	1.2^{a}	7.2^{a}
SP2	25^{a}	69^{b}	6^{a}	15^{b}	2.4c	6.6^{c}	1.0^{a}	8.0^{a}
SP3	18^{b}	67^{b}	9^{a}	17^{ab}	2.6^{bc}	8.4^{b}	0.8^{a}	5.2^{b}
SP4	22^{ab}	36^{c}	7^{a}	15^{b}	3.4^{a}	6.6^{c}	1.1^{a}	7.2^{a}
SP5	20^{ab}	36^{c}	7^{a}	13^{b}	2.9^{abc}	6.8^{c}	0.9^{a}	8.0^{a}
SP6	24^{ab}	96^{a}	8^{a}	21^{a}	3.1^{ab}	8.8^{ab}	0.8^{a}	5.2^{b}
Mean	21^{b}	62^{a}	8^{a}	16^{b}	2.83^{a}	7.77^{a}	0.97^{a}	6.80^{a}
Baduria								
BP1	22^{a}	65^{a}	8^{a}	22^{b}	2.4^{a}	8.0^{ab}	1.2^{a}	5.6^{a}
BP2	20^{a}	67^{a}	9^{a}	28^{ab}	2.8^{a}	7.4^{bc}	1.1^{a}	4.0^{b}
BP3	17^{a}	67^{a}	7^{a}	33^{a}	2.9^{a}	5.6^{d}	0.8^{a}	5.2^{a}
BP4	21^{a}	43^{b}	8^{a}	22^{b}	2.6^{a}	6.6^{c}	0.7^{a}	5.6^{a}
BP5	23^{a}	50^{b}	6^{a}	23^{b}	3.0^{a}	4.8^{d}	1.0^{a}	5.6^{a}
BP6	20^{a}	69^{a}	9^{a}	10^{a}	2.8^{a}	8.8^{a}	0.9^{a}	4.8^{ab}
Mean	21^{b}	60^{a}	8^{a}	23^{a}	2.75^{a}	6.87^{b}	0.95^{a}	5.13^{c}
Swarupnagar								
SNP1	30^{a}	69^{ab}	9^{ab}	28^{b}	2.0^{b}	7.4^{ab}	0.9^{abc}	5.2^{b}
SNP2	29^{ab}	62^{b}	8^{ab}	25^{b}	2.4^{ab}	6.6^{b}	1.0^{ab}	6.8^{a}
SNP3	22^{cd}	74^{a}	10^{a}	10^{c}	2.6^{ab}	7.8^{a}	0.8^{abc}	5.6^{b}
SNP4	24^{c}	69^{ab}	7^{ab}	38^{a}	2.8a	8.2^{a}	0.6^{c}	6.0^{ab}
SNP5	25^{bc}	65^{ab}	9^{ab}	13^{c}	3.0^{a}	8.0^{a}	1.1^{a}	5.6^{b}
SNP6	19^{d}	74^{a}	6^{b}	26^{b}	2.8^{a}	7.6^{ab}	0.7^{bc}	5.6^{b}
Mean	25^{a}	69^{a}	8^{a}	23^{a}	2.60^{a}	7.60^{ab}	0.85^{a}	5.80^{b}

Value represented by the same superscripts in a column are statistically similar at 5% probability level by DMRT

water in Baduria varied from 6.27 to 6.65 with a mean value of 6.49. Irrespective of the places, the fungal cfu of the post-retting water was higher than the pre-retting water samples. The mean fungal cfu of pre-retting water was 3.48 in Sonatikari, 3.29 in Baduria and 3.23 in Swarupnagar. The highest mean fungal cfu of the post-retting water was found in Sonatikari (5.57, range 5.32 to 5.72) and the lowest in Swarupnagar (5.03, range 4.84 to 5.32) (Table 3). The mean pectinolytic bacterial cfu of pre-retting water was 3.31 in Sonatikari, 3.11 in Baduria and 3.17 in Swarupnagar. The same values at the post-retting period increased to 5.24 in Sonatikari, 5.10 in

Table 3: Microbiological parameters of jute retting water samples

	Log value of colony forming unit							
	Bacterial cfu		Fungal cfu		Pectinolytic cfu		Spore forming bacterial cfu	
Village	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Sonatikari								
SP1	4.28^{bc}	6.22^{b}	3.60^{ab}	5.65^{ab}	3.34^{a}	5.27^{b}	3.60^{a}	5.48^{b}
SP2	4.32^{ab}	6.85^{a}	3.45^{c}	5.53^{c}	3.27^{ab}	5.32^{ab}	3.48^{b}	5.41^{b}
SP3	4.35^{a}	6.86^{a}	3.53^{bc}	5.32^{d}	3.32^{a}	5.32^{ab}	3.41^{c}	5.28^{c}
SP4	4.26^{bc}	6.22^{b}	3.32^{d}	5.54^{bc}	3.40^{a}	5.40^{a}	3.55^{a}	5.30^{c}
SP5	4.22^{c}	6.83^{a}	3.26^{d}	5.72^{a}	3.36^{a}	5.16^{c}	3.30^{d}	5.48^{b}
SP6	4.30^{ab}	6.93^{a}	3.70^{a}	5.63^{abc}	3.16^{b}	4.94^{d}	3.38^{c}	5.57^{a}
Mean	4.29^{b}	6.65^{a}	3.48^{a}	5.57^{a}	3.31^{a}	5.24^{a}	3.45^{a}	5.42^{a}
Baduria								
BP1	4.55^{a}	6.54^{ab}	3.30^{bc}	5.24^{a}	3.23^{a}	5.27^{a}	3.30^{b}	5.25^{c}
BP2	4.34^{b}	6.46^{b}	3.24^{c}	5.15^{bc}	3.30^{a}	4.87^{c}	3.45^{a}	5.11^{d}
BP3	4.26^{bc}	6.54^{ab}	3.15^{d}	5.08^{c}	2.87^{c}	4.95^{c}	3.28^{b}	5.48^{b}
BP4	4.20^{c}	6.27^{c}	3.28^{bc}	5.28^{a}	2.95^{c}	5.23^{a}	3.40^{a}	5.30^{c}
BP5	4.27^{bc}	6.46^{b}	3.37^{ab}	4.95^{d}	3.23^{a}	5.09^{b}	3.24^{b}	5.32^{c}
BP6	4.46^{a}	6.65^{a}	3.40^{a}	5.20^{ab}	3.09^{b}	5.21^{a}	3.32^{b}	5.58^{a}
Mean	4.35^{ab}	6.49^{b}	3.29^{b}	5.15^{b}	3.11^{b}	5.10^{b}	3.33^{b}	5.34^{ab}
Swarupnagar								
SNP1	4.43^{b}	6.47^{ab}	3.30^{a}	5.15^{b}	3.32^{a}	4.99^{c}	3.48^{a}	5.24^{c}
SNP2	4.47^{a}	6.29^{cd}	3.15^{bc}	5.08^{bc}	2.99^{d}	5.14^{b}	3.24^{d}	5.39^{ab}
SNP3	4.29^{d}	6.20^{d}	3.08^{c}	4.96^{cd}	3.24^{ab}	5.27^{a}	3.39^{abc}	5.10^{d}
SNP4	4.35^{c}	6.30^{cd}	3.26^{ab}	5.32^{a}	3.27^{a}	5.20^{ab}	3.37^{bc}	5.42^{a}
SNP5	4.30^{d}	6.41^{bc}	3.32^{a}	4.86^{d}	3.04^{cd}	5.03^{c}	3.42^{ab}	5.33^{b}
SNP6	4.41^{b}	6.57^{a}	3.27^{ab}	4.84^{d}	3.13^{bc}	5.16^{b}	3.30^{cd}	5.20^{c}
Mean	4.38^{a}	6.37^{b}	3.23^{b}	5.03^{c}	3.17^{b}	5.13^{b}	3.37^{b}	5.28^{b}

Value represented by the same superscripts in a column are statistically similar at 5% probability level by DMRT

Baduria and 5.13 in Swarupnagar. The spore forming bacterial cfu of pre-retting water varied from 3.30 to 3.60 (mean 3.45) in Sonatikari, 3.24 to 3.45 (mean 3.33) in Baduria and 3.24 to 3.48 (mean 3.37) in Swarupnagar. Sonatikari recorded the highest mean spore forming bacterial cfu (5.42, range 5.28 to 5.57) at post-retting period and Swarupnagar recorded the lowest value (5.28, range 5.10 to 5.42). The mean spore forming bacterial cfu in Baduria was 5.34 with a range of 5.11 to 5.58 at post-retting period (Table 3).

DISCUSSION

The physico-chemical and microbiological parameters of the water samples varied significantly between the ponds. Irrespective of the locations, the pH of the pre-retting water samples was neutral to slightly alkaline, while the same for post-retting was acidic. Donaghy *et al.* (1990) also observed the same phenomenon. The lowering of pH values of post-retting water samples is related to the release of organic acids like butyric, acetic and lactic acid during microbial metabolism of sugars, pectins and other gummy materials (Ahmed and Akhter, 2001). The Ec, a measure of soluble salts in water, of the post-retting water in all the water samples were significantly higher than pre-retting water. It is a fact that the ash content is very high in jute ribbon which is due to the presence of polyuronides or pectins as their metallic salts (Majumdar and Dey, 1977). In the ash of ribbon, Calcium (Ca), Magnesium (Mg) and Iron (Fe) were detected. Increase in Ec in the retting ponds could be attributed either to the release of salts from jute samples or from the ill practice of using mud to submerge the jute bundles. The COD is used as a measure of the oxygen equivalent of the organic matter content of a sample that is susceptible to oxidation by a strong chemical oxidant. Basically, COD measurement aims to determine the degree of pollution by biodegradable and non-biodegradable organic matter (Chowdhury and Zaman, 2001). Results indicated that the COD values of the retting waters herein were within the environmental control limit. The range of COD values, during the post-retting period, was much less, but the total hardness of the retting water samples recorded higher values than previously reported (Ahmed and Nizam, 2008) which is contradictory to the findings of the present study. Quality of fibre is better when retting water is soft than when hard water is used. This explains why successive retting in the same water bodies produce poor quality jute. The hardness of water is caused by the bicarbonate and chloride salts of calcium and magnesium. Irrespective of the places, the increase in hardness of post retting water samples could be attributed to the release of these two anions during retting.

The microbiological parameters of the post-retting water samples were always higher than pre-retting samples. The jute plants, when steeped in water, absorb

water and swell and ultimately burst at several places thus liberating the soluble constituents that include sugars, glucosides and nitrogenous compounds (Ali and Islam, 1963; Ali *et al*., 1976). These substrates create favourable environment for the growth of microorganisms present in water as well as in the plants. Higher microbial load of the post retting water samples herein could be related to the availability of biogenic materials at the disposal of the microorganisms (Ahmed *et al*., 2002). Retting is a process by which the pectic materials that bind the fibres to the remainder of the stem are broken down and the fibres are liberated (Shamsul Haque *et al*., 2003). Pectinolytic microorganisms play a dominant role in producing quality and quantity of jute fibre (Tamburini *et al*., 2003). Thus, along with conventional microbial count, pectinolytic microorganisms in jute retting water were also enumerated. The result clearly demonstrated that a significant part of the bacterial populations were spore-former, indicating their dominant role in jute retting.

CONCLUSION

Results clearly demonstrated that jute retting deteriorates water quality which may be detrimental to jute quality when successive rettings are carried out in the same pond. This may also pose problem to pisciculture. Remedial measures to improve the water quality after each retting charge in the pond seem essential, particularly for the ponds where pisciculture is to be undertaken.

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