

## Effect of conventional retting of jute on the quality of water and jute fiber

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### ABSTRACT

Jute is a natural fiber also known as golden fiber in Bangladesh. Jute fiber is commonly extracted from the plant after immersion in water bodies. The traditional jute retting process harms the quality of jute fiber as well as water where jute plants were immersed as it decomposes bio-mass and hampers different water quality indicating parameters. In this study water samples were collected from different ponds and ditches at Muktagacha Upazilla, Mymensingh, Bangladesh in July 2020. Samples were collected from jute pre- and post-retting water bodies. The study was conducted to monitor the effect of jute retting on various physicochemical and microbiological parameters like- pH, total dissolved solids (TDS), electrical conductivity (EC), and dissolved oxygen (DO). All parameters were measured at the central laboratory of Bangladesh Agricultural University using a Multiparameter waterproof meter with a probe. To examine water quality, water samples were collected three times from five particular water bodies of stagnant waters, and the freshwater of the canal and pond. Water quality parameters of pre and post-retting jute water were found as pH 6.42~7.02 and 6.10~5.59, TDS 18~81 mgL<sup>-1</sup> and 103~183 mgL<sup>-1</sup>, DO 2.3~2.4 mgL<sup>-1</sup> and 0.8~0.9 mgL<sup>-1</sup>, and EC 36~163 μScm<sup>-1</sup> and 222~396 μScm<sup>-1</sup>, respectively. A comparison was made with the standard values of water quality parameters and found notable differences with the Department of Environment standards of Bangladesh. Another observation was also made to determine whether the retting water can influence fiber quality or not. Observed results indicated that a low level of pH and DO in jute retted water in a pond may not be suitable for fish cultivation. On the other hand, higher content of TDS and EC in post jute retting water was found responsible for the poor quality of jute fiber.

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### Introduction

Jute (*Corchorus spp.*), kenaf (*Hibiscus cannabinus*) and mesta (*Hibiscus sabdariffa*) are grown commonly in Bangladesh for fiber production (Islam, 2019). Jute is a natural, least expensive, biodegradable, and versatile textile fiber of great commercial importance (Twari and Khatri, 2017). Next to the ready-made garments, jute and jute goods of Bangladesh are the second-largest export product in the international market (Begum, 2016) and jute fiber of Bangladesh holds more than 70% of the share in the world market after India (Hossain and Abdulla, 2015). Export of jute

products and raw jute was recorded BDT64.329 billion in July- January of the FY 2018-19 which consists of jute products BDT 54.687 billion and raw jute BDT 9.642 billion (Export Receipts, 2020).

Jute has numerous points of interest over synthetics and keeps up the environmental adjust. Jute is not only a source of fiber used in diversified traditional products but also a crude fabric for non-traditional and esteem included non-textile items. As of late jute strands are utilized in a wide run of broadened items: embellishing textures, chic-saris, salwarkamizes, delicate luggage's,

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footwear, welcoming cards, molded entryway boards and other endless valuable customer items (Ghosh and Jethi, 2013; Hossain and Abdulla, 2015). Jute products are utilized broadly for conventional bundling textures, widely used for designing and aesthetic purposes like embroidered paintings, framed photographs, wall hangings, wall decals, bags, craftwork, textiles, apparel, and furnishing (Akter *et al.*, 2020).

Around four million farmers in Bangladesh are involved in the jute sector (Molla, 2014; Islam *et al.*, 2015) where around 0.16 million employees are worked directly in different jute mills of the country (Uddin *et al.*, 2014). In our country, traditional stem retting, and ribbon retting are commonly practiced by the most farmer for jute fiber extraction (Ali *et al.*, 2015). The quality of jute fiber i.e. strength, texture, luster, and color not only depends on jute retting processes (IJSG, 2009; Karim *et al.*, 2021) but also the availability and quality of suitable water bodies for retting (Das *et al.*, 2011).

According to BBS, in the year 2017-2018 and 2018-2019, the total jute production was recorded 8.89 and 8.58 million bales, respectively, and found a reduction in the production of about 3.58% (BBS, 2019). Despite holding the second position with a huge request of hi-tech jute products over the globe (Begum, 2016), the jute retting process is still conventional in Bangladesh. Retting is the foremost vital single figure which rules the quality of jute fiber and is directly influenced by the process of retting (IJSG, 2009).

The conventional whole stem retting contaminated the water bodies as well as the environment by biomass decomposition which hampers the quality of jute fiber (Husain, 2011). In water-based jute retting, the quality of fiber and water depends on diverse parameters like the sum of TDS (lower content of salt, iron and calcium), pH value, temperature, hardness (soft water), EC, color, and odor of water (Roy and Hassan, 2016; Majumdar *et al.*, 2019).

Water plays a prevailing part in deciding the quality of jute fiber (Das *et al.*, 2014). In stagnant water bodies, natural mass discharged by jute retting increased microbial movement and prolonged O<sub>2</sub> depletion which makes the water darker with terrible odor and passing misfortune in retting water and fiber quality (Haque *et al.*, 2002).

It was recommended that about 15 cm water is cleared out over the top layer of the bundle of jute stems of an average 20 cm diameter in size under plant water proportion about 1:20 with optimum retting temperature of water bodies 34°C (Ahmed and Akhter, 2001; Das *et al.*, 2014) and submerged for 5–15 days in shallow water to enhance microbial activity, leading to releasing of jute fibers from the stem (Roy and Hassan, 2016).

Slow-moving clean water bodies consisting of low contents of iron and calcium freed tanning from jute stems during retting and created Fe–tannate capable for dark patches on fiber. The hardness of the retting water also increases as the solid substances extract much from the jute fiber during retting (Jarman, 1985).

Akhter (2014) analyzed the quality of pre and post-retting water and concluded that jute-retting may not be the only reason for water quality deterioration of ponds. Das *et al.*, (2011) also found huge changes in fiber and water quality measuring parameters such as pH, EC, chemical oxygen demand (COD), hardness, biochemical oxygen demand (BOD), Calcium (Ca), Magnesium (Mg), bicarbonate, chloride content, etc. in pre and post retting jute water. Jute plant age is also considered an important parameter to fiber quality and efficient retting. Ahmed and Akhter (2001) found 17.3% and 9.5% fiber loss when ribbons were carried out 75 and 120 day's old jute plant, respectively.

In Bangladesh, rivers, canals, and ponds are considered as main water bodies for fish production and breeding with virtually no control over the water volume, water quality (pH), temperature and total dissolved solids (Ahmed and Nizam, 2008). In the traditional jute retting process along with these water bodies, artificial

ditches were also established using polythene to not interrupt the fish biodiversity. In these cases, an adequate water supply must be ensured for proper retting. Different water bodies used for jute retting became polluted and turned black, odorous, and stinky, as well as hampers fish production and their breeding system (Ali *et al.*, 2015). In Bangladesh, at the peak season of jute retting, water stands for a short period in water bodies due to climatic changes and affected the retting process. Thereby adversely affecting the quality of the jute fiber and water along with the aquatic lives (Roy and Hassan, 2016).

Jute retting and fiber collection methods have a profound effect on fiber quality as well as on the fiber production cost (Jahan *et al.*, 2016). On the other hand, water quality is the most important factor affecting fish health and performance in aquaculture production systems for other microorganisms (Shafei, 2016). Biomass decomposition by jute retting process especially in case of whole stem retting would be responsible for water pollution which hampers the water quality parameters and finally responsible for water pollution as well as poor quality fiber. Therefore, it is fundamental to consider in the study how water quality deteriorates in jute retting water bodies and how it influences fish cultivation. In the study, not only the water quality parameters were measured from jute pre- and post-retting water bodies but also observed the jute fiber quality.

## Materials and Methods

**Location selection:** The study was conducted at Muktagacha Upazila of Mymensingh district which is well known for fertile loamy texture soil of old Brahmaputra floodplain, with pH 5.32- 6.46 (Sheel *et al.*, 2016) suitable for jute cultivation (Ali *et al.*, 2015). The experimental site was characterized by the temperature of 25.8<sup>o</sup>C to 31.2<sup>o</sup>C and humidity of 35% to 39% in July with average normal rainfall of 436.3 mm occasionally.

**Sample collection:** Muktagacha Upazila is one of the water rare regions of Mymensingh. The availability of sufficient water during jute retting preparation hampers the retting even though farmers cultivated jute at a suitable time. Jute plants are generally harvested after 100-130 days of cultivation depending upon the variety to get strong and matured fiber (Das *et al.*, 2014) and in the study, Mesta of 95-100 days old were harvested for retting to collect jute fiber.

Ponds, canals, and lower ranges with fresh and stagnant water were utilized for retting jute from different areas of Muktagacha. Jute farmers of Muktagacha most commonly used stagnant water bodies for jute retting to avoid water pollution of ponds and canals used for fish cultivation. Jute stem bundles of about 10cm diameter were immersed in stagnant water bodies of almost 70 to 90 cm deep as well as in freshwater ponds and canals of 120 to 160 cm deep for 15 days to separate fiber from the stem.

Water samples were collected from the top layer of water bodies from retting zones where jute plants were immersed based on the field condition by using plastic bottles. Samples from five distinct locations at three different stages of the jute retting period were collected. Firstly, pre-retting water quality parameters were determined before the retting of jute in the ditches, secondly, water samples were collected on the 6<sup>th</sup> day of retting, and finally on the 15<sup>th</sup> day and which is the last day of jute retting. The samples were at that point promptly transported to the central laboratory, Bangladesh Agricultural University (BAU), Mymensingh, and maintained 4<sup>o</sup>C temperature for preservation in a refrigerator.

**Sample analysis:** Measured water quality parameters were turbidity, hardness, pH, color, phosphate, biochemical oxygen demand (BOD), dissolved oxygen (DO), chemical oxygen demand (COD), total solids (TS), total suspended solids (TSS), total dissolved solids (TDS), total coliform, electrical conductivity (EC), temperature (Roy and Hassan, 2016). In the study, all measured quality parameters were compared

with the standard values to investigate the water quality pre and post jute retting according to the Department of Environment (DOE), Bangladesh. Table 1 shows the standard allowable limits of pH, DO, TDS, and EC of the Department of Environment (DOE), Bangladesh (Akter *et al.*, 2019; Roy and Hassan, 2016).

**Table 1.** Allowable limits of pH, DO, TDS and EC with DOE standard for fish cultivation.

Parameter	Unit	DOE standard for fish
pH	-	6.5-9
TDS	mgL <sup>-1</sup>	152-350
DO	mgL <sup>-1</sup>	4-6
EC	µScm <sup>-1</sup>	0-5000

Microbiological investigations like- pH, DO, TDS, and EC of collected water samples were moreover carried out within 3-4 days of collection. All the data were measured by a Multi-parameter Waterproof Meter with a 10 cm cable probe, (HANNA instruments, H198194/10, Romania) by dipping the probe into the sample. The temperatures of the retting ponds were recorded from the collected water sample by using a Multi-parameter Waterproof Meter immediately after collection and found a range of 32°C-34°C.

In the study, jute fiber was collected from the farmers to investigate the effect of jute retted water on jute fiber and checked some physical properties of fiber-like color, shininess, and spot by on-field visual observation. The impact of jute retted water on fish cultivation was also observed based on pH, TDS, EC, and DO of jute retted water bodies.

**Data analysis:** After measurement of water quality parameters in pre-and post-retting stages, all data were subjected for the statistical analyses using MS Excel 2013. Firstly, standard deviation (SD) of pre-and post-retting water, TDS, EC, and DO was calculated. Secondly, standard error (SE) was measured from SD by dividing with the number of samples (five) to

represent the error bar in bar diagrams of individual samples for pre and post jute retting water.

## Results and Discussions

**Water quality parameters of collected samples:** In the study water quality parameters like pH, TDS, EC, and DO were measured for pre and post jute retting water collected from the five particular water samples of the canal, pond, stagnant water body 1, stagnant water body 2, and stagnant water body 3 as shown in Table 2. A general observation of TDS and EC of water samples were found increased in all ponds/canals, on the other hand, pH and DO were decreased with the retting time progresses to end due to the increased microbial activities. The levels of pH, TDS, EC and DO of jute retted water varies from the quality of water standard for fish cultivation mentioned by DOE (Roy and Hassan, 2016) and other water quality assessment studies (Akter *et al.*, 2019; Munni *et al.*, 2015).

**Comparisons of water quality in pre and post jute retting water bodies:** The pH of five water sources has shown in Figure 1 and found notable differences for pre and post jute retting water collected. The pH values of water samples collected from the canal, pond, stagnant water body 1, stagnant water body 2, and stagnant water body 3 on the last (15<sup>th</sup>) day of retting were decreased 5%, 8.3%, 3.9%, 16.6%, and 17.5% respectively than that of water samples before starting the jute retting. In the study, post-retting water samples were observed slightly acidic than the pre-retting water samples as the organic acid diffuses at the time of fiber separation due to microbial decomposition in post-retting water (Roy and Hassan, 2016).

The pH of water is considered as a degree of how corrosive or alkaline it is, on a scale of 0 to 14 with 7 being neutral. All pre retting water samples collected were found alkaline in nature (Akter *et al.*, 2019). Pre and post-retting samples were taken from water bodies during daytime as plants in water evacuate carbon dioxide (CO<sub>2</sub>) for photosynthesis to enhance pH initiation (Stone and Thomforde, 2004).

In post jute retting water microbial activities were observed highest with more biochemical oxygen demand (BOD<sub>5</sub>) causes more DO consumption and

finally decreasing the CO<sub>2</sub> evacuation from water (Khan *et al.*, 2017; Roy and Hassan, 2016).

**Table 2.** Top layer water quality parameters of pre and post jute (Mesta) retting water from different water bodies.

Sample number	Water sources	Time	pH	TDS mgL <sup>-1</sup>	EC μScm <sup>-1</sup>	DO mgL <sup>-1</sup>
1	Fresh water from canal	Pre-retting	6.79	53	106	2.3
		6 <sup>th</sup> day of retting	6.61	62	135	1.7
		15 <sup>th</sup> (final) day of retting	6.45	121	262	0.9
2	Fresh water from pond	Pre-retting	6.65	39	77	2.4
		6 <sup>th</sup> day of retting	6.49	58	124	1.7
		15 <sup>th</sup> (final) day of retting	6.10	167	359	0.8
3	Stagnant water body 1	Pre-retting	6.42	47	99	2.4
		6 <sup>th</sup> day of retting	6.31	158	342	1.5
		15 <sup>th</sup> (final) day of retting	6.17	179	389	0.8
4	Stagnant water body 2	Pre-retting	6.70	81	163	2.4
		6 <sup>th</sup> day of retting	5.77	87	188	1.1
		15 <sup>th</sup> (final) day of retting	5.59	183	396	0.9
5	Stagnant water body 3	Pre-retting	7.02	18	36	2.3
		6 <sup>th</sup> day of retting	5.91	64	138	1.8
		15 <sup>th</sup> (final) day of retting	5.79	103	222	0.8

Figure 2 shows the TDS content for pre and post-retting jute water. TDS content of the water samples after retting increased 128.3%, 328.2%, 280.9%, 125.9%, and 472.2% in the canal, pond, stagnant water body 1, stagnant water body 2, and stagnant water body 3, respectively than that of pre retting water. Before jute retting water bodies contain a very low amount of TDS as recommended less than 400mgL<sup>-1</sup> (Davis, 1993; Meade, 2012).

TDS signifies a build-up of dissolved solids in pond water and has a positive relationship with total alkalinity and chloride (Mohini *et al.*, 2013). James, 2019 observed TDS most likely increases with mineral formation, and algae promoting supplements. Moreover, the salt concentration of pond water also raises the TDS as salt does not evaporate with the water. TDS also denotes the inorganic contamination

stack of a water framework (Usha *et al.*, 2008). In the study, increased microbial movement due to solids extracted from jute plants along with algae formation increases the TDS content within the acceptable range for post-retting water. On the other hand, daytime sample collection enhances the probability of evaporation helps to salt accumulation, and increases TDS in pond water.

Electrical conductivity is a measure of total salt concentration in water. In the study, EC of different water bodies was measured and observed that EC of post retting jute water increased significantly as 147.2%, 366.2%, 292.9%, 142.9%, and 516.7% in the canal, pond, stagnant water body 1, stagnant water body 2 and stagnant water body 3, respectively than that of jute pre retting water shown in Figure 3. EC values of post retting water samples ranged from 163

*Retting jute on the quality of water and jute fiber*

$\mu\text{Scm}^{-1}$  to  $396 \mu\text{Scm}^{-1}$  belongs to the recommended range (Majumdar *et al.*, 2019) and can be utilized to allow a rough assessment of the total dissolved solids ( $\text{mgL}^{-1}$ ) and found TDS half of EC ( $\mu\text{Scm}^{-1}$ ) (Stone and

Thomforde, 2004). TDS in water primarily shows the presence of different minerals and improves the ionic trades in water (Huq and Alam, 2005).

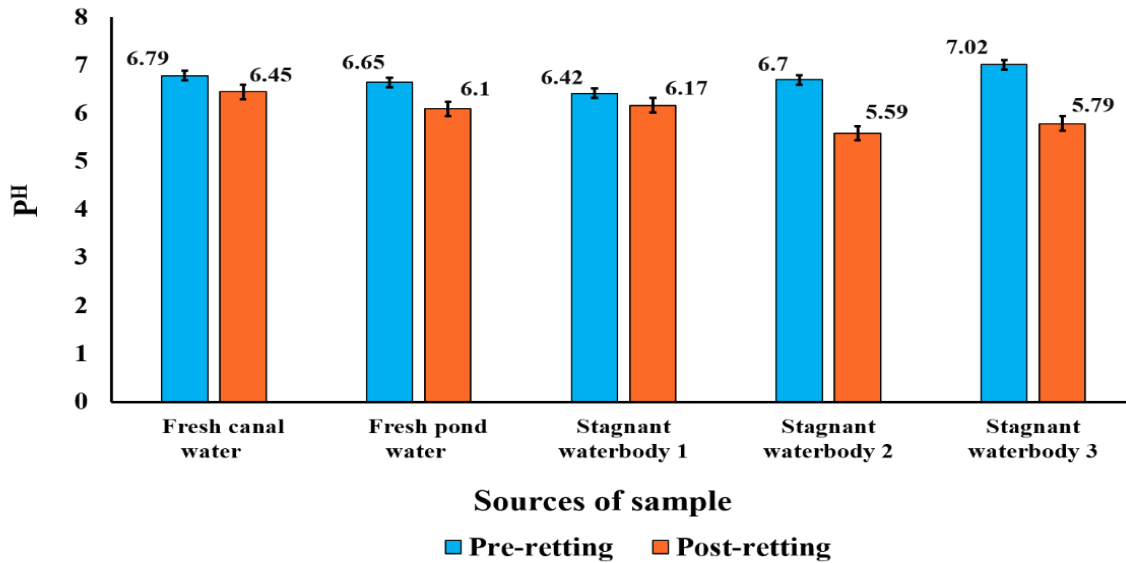


Figure 1.  $\text{pH}$  of pre and post jute retting water

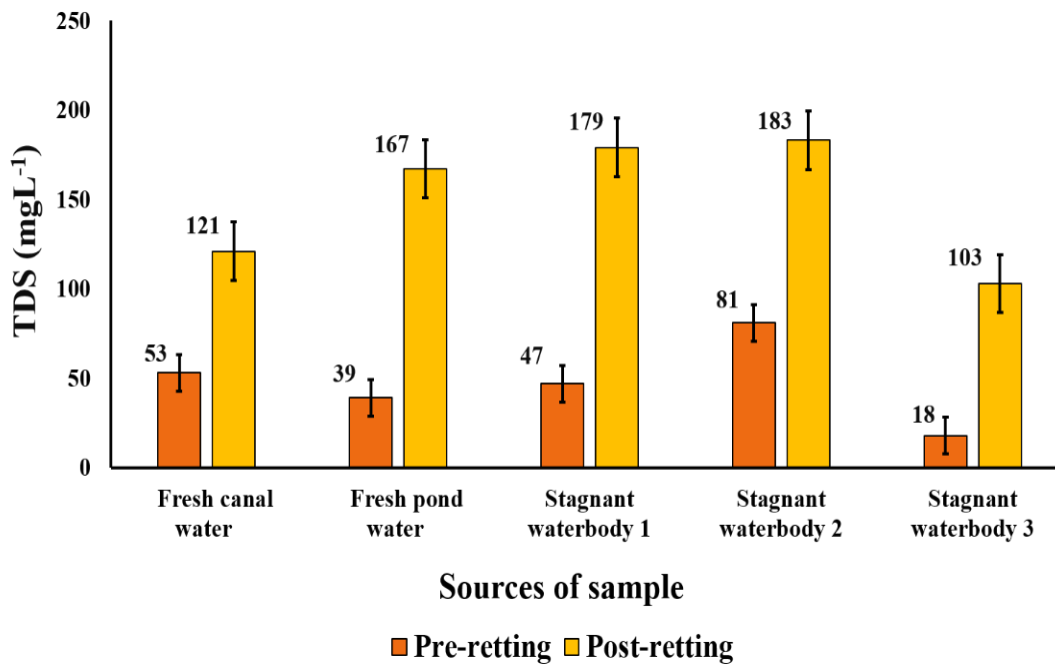
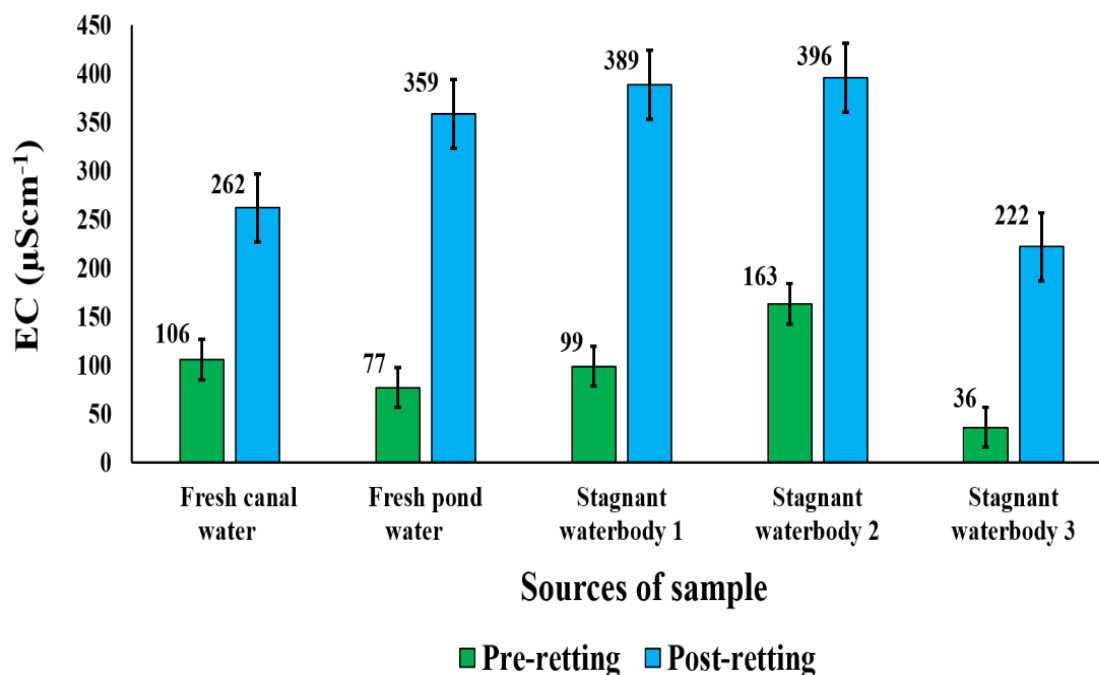


Figure 2. Total Dissolved Solid (TDS) content of pre and post jute retting water.



**Figure 3.** Electrical Conductivity (EC) of pre and post jute retting water.

In the present study the value of TDS increased in post-retting jute water as well as EC increased and found almost half as suggested. In pre and post-retting water samples of Nadia and Haringhata, India, EC was recorded between 254 and 300  $\mu\text{Scm}^{-1}$ , and 535 and 850  $\mu\text{Scm}^{-1}$ , respectively (Majumdar *et al.*, 2019).

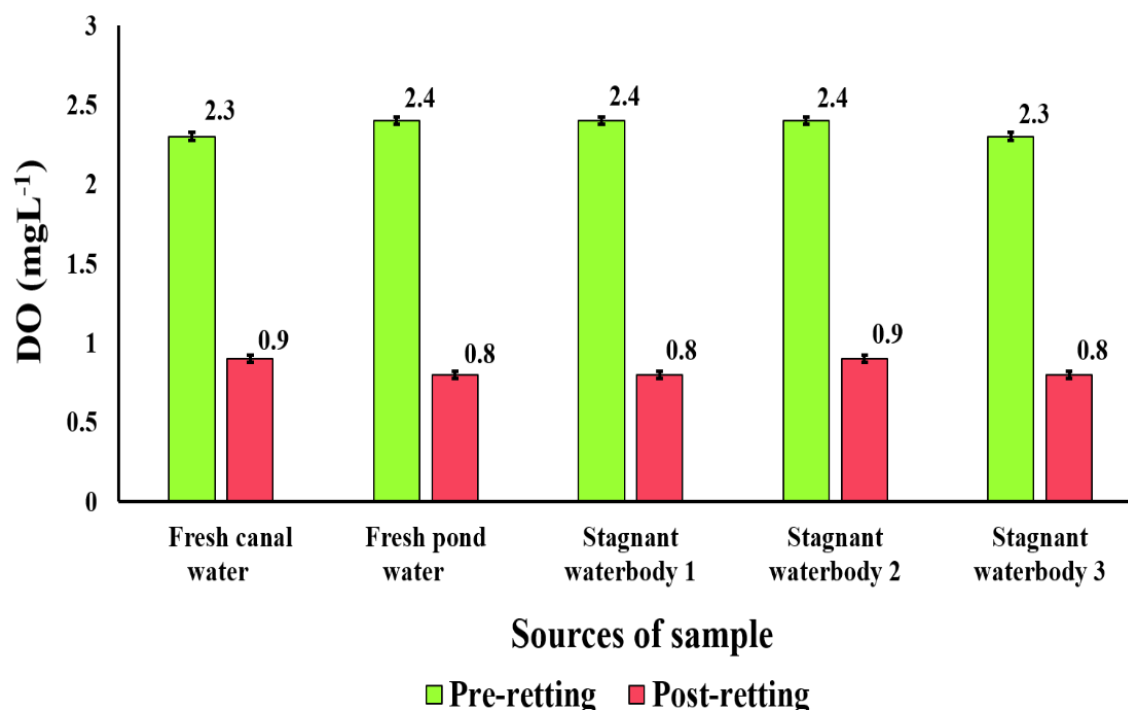
The expansion of salts like Mg, Fe, Ca, etc. by their discharge from the fiery debris of jute plants during the method of jute retting in bio decomposition of pectins, polyuronides, etc. might be causing the EC to increase (Majumdar and Dey, 1977).

In warmer months DO concentration diminishes in water as the oxygen dissemination rate diminished. DO correlate adversely with increased temperature and salinity, low atmospheric pressure, high humidity, high concentration of submerged plants, and plankton blooms (Bhatnagar and Devi, 2013; Kataria *et al.*, 1996; Sangu and Sharma, 1987). The study samples were collected at day time of warmer months and found a lower concentration of DO ( $2.4 \text{ mgL}^{-1}$ ) in pre

retting water samples than that of standard value. DO concentrations were shown in Figure 4 and found decreasing in post retting water at the rate of 60.9%, 66.7%, 66.7%, 62.5%, and 65.2% in the canal, pond, stagnant water body 1, stagnant water body 2, and stagnant water body 3, respectively compared to water samples before retting.

DO was found in jute retting water ranges  $1.0\text{-}1.5 \text{ mgL}^{-1}$  which are below the standard DO ( $2 \text{ mgL}^{-1}$ ) and unfavorable for fish cultivation (Roy and Hassan, 2016). Several reasons for bringing down the DO level in jute retting water were distinguished. Numerous microscopic organisms with an overabundance sum of biochemical oxygen request (BOD) indicated DO level reduction in jute retting water (Bhatnagar and Devi, 2013). As the sun warms the water bodies directly when jute is kept in open space to rot may cause diminish DO levels in stream water. In warm water, molecular action also increased and pushes the oxygen particles out of the spaces between

the moving water particles (Mohini *et al.*, 2013; Roy and Hassan, 2016).



**Figure 4.** Dissolved Oxygen (DO) content of pre and post jute retting water

**Impact of jute retted water on fish cultivation:** Quality assessment of water for fish cultivation at Shambhuganj, Mymensingh has investigated the temperature, pH, DO, EC, and TDS and found 28.5 °C, 7.9-8.4, 6.8-7.8 mgL<sup>-1</sup>, 231.5-307.2 μScm<sup>-1</sup>, and 146-200 mgL<sup>-1</sup>, respectively (Mou *et al.*, 2019). Another study with conventional jute retting recorded lower pH 6.22 to 7.08 and higher EC of 509 to 850 μScm<sup>-1</sup> for post retting water compared to pre retting water of pH 6.63 to 7.44, and EC 197 to 330 μScm<sup>-1</sup> (Majumdar *et al.*, 2019).

Roy and Hassan (2016) detected pH and DO of collected water samples from post jute retted ponds were 3-3.5 and 1-1.5 mgL<sup>-1</sup>, respectively responsible for contamination of the aquatic environment. Another observation on jute pre and post retting water from selected ponds of Bangladesh was conducted to determine water regarding parameters like TDS (213

to 501 mgL<sup>-1</sup> and 210 to 595 mgL<sup>-1</sup>, respectively) and pH (6 to 9, respectively) and considered that jute-retting may not be the only reason of water pollution of ponds (Akhter, 2014).

The study area Muktagacha is a well-recognized, commercial fish culture area and normally jute retting is not allowed in ponds and ditches. As the natural process of jute retting has virtually no control over the water quality parameters, stem retting of jute causes a bad stench to the fish body and reduces the market price of the cultured fish (Ahmed and Nizam, 2008). In the study different water quality parameters were measured and found lower DO (0.8mgL<sup>-1</sup>), and pH (5.5) in post retted water, which may harm fish cultivation.

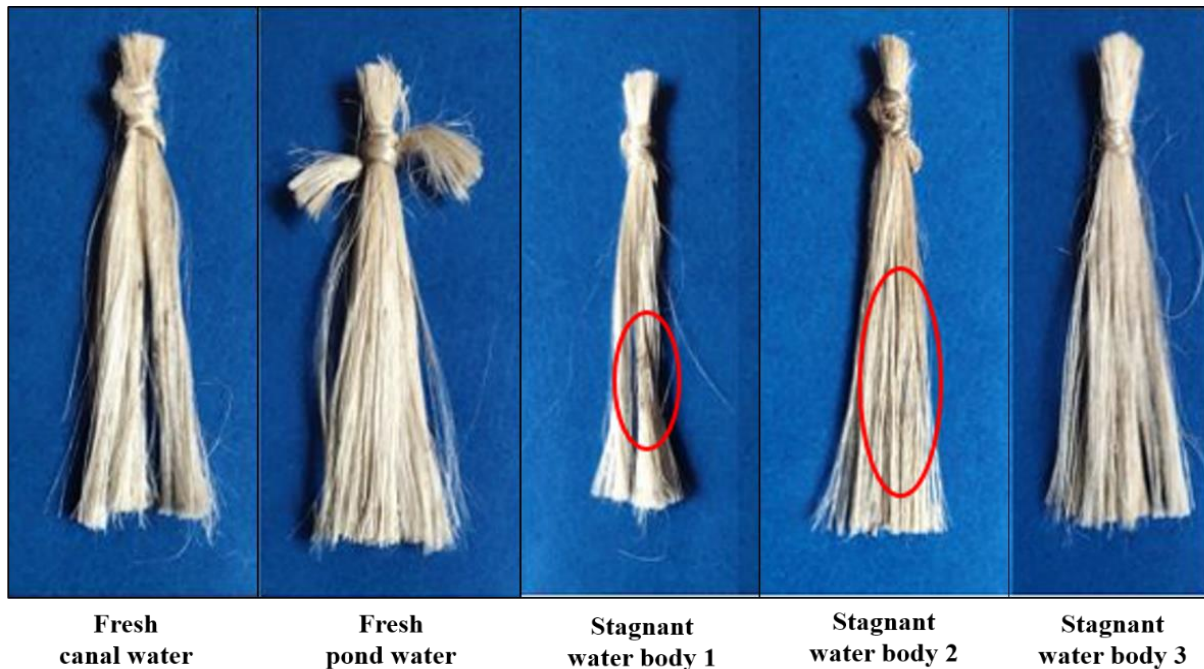
**Relationship between fiber and water quality:** Progressive retting within the same water bodies delivers the destitute quality of jute fiber (Das *et al.*,



2014; Khan *et al.*, 2017). TDS indicates the degree of dissolved combined substance of all inorganic and natural substances display in a fluid in atomic, ionized, or micro-granular suspended frame and found relatively low at pond water less than  $365 \text{ mgL}^{-1}$  (Akter *et al.*, 2019; Usha *et al.*, 2008). In the present study, TDS was observed higher in post jute retting water than in pre retting water especially in samples of the pond and stagnant water bodies 1, and 3 due to an increase of dissolved solid by microbial activity with the process of retting shown in Figure 2.

As the EC is related to the salt content of dissolved solids which can assess generally the sum of TDS and found proportional to TDS (Moran, 2018; Stone and

Thomforde, 2004). In the study Figure 3 shows ECs of the pond and stagnant water body 1, and 3 are comparatively higher in post jute retting water than that of acceptable range in freshwater bodies (Majumdar *et al.*, 2019) due to higher concentration of major ions from TDS (Akter *et al.*, 2019). Increased EC enhances ionic imbalance and also creates Fe-tonnage responsible for dark color and small black spot on fiber shown in Figure 5 collected from nearly bottom part of the plant indicates poor quality of jute fiber. Stagnant water bodies and ponds with a lower volume of water adversely affect the water as well as fiber quality than that of freshwater sources after jute retting was also observed from Figures 2, 3 and 5.



**Figure 5.** Jute fiber collected after retting from the canal, pond, stagnant water body 1, stagnant water body 2, and stagnant water body 3 from selected areas of Muktagacha, Mymensingh. The marked red circle in collected samples from stagnant water bodies 1 and 2 shows the black patches and spots due to higher TDS and EC content in post jute retting water.

The pH of post-retting water was slightly acidic 6-5 (Figure 1) in the study and found no effect on fiber quality. Normally slightly acidic water shortens the jute retting period although pH level neutral or alkaline of

freshwater bodies is recommended for retting (Ali and Alam, 1973). Optimum water temperature during retting was found  $34^{\circ}\text{C}$  matched with the recommended

value mentioned by Ahmed and Akhter (2001) and Das et al., (2014).

### **Conclusions**

The study investigated the water quality of pre and post jute retting water bodies as well as the fiber quality which varies notably with the quality of water. Measured water quality parameters like pH, TDS, EC, and DO were changed notably in post retting water than that of pre retting water. The p<sup>H</sup> and DO of water were decreased in all collected samples on the last day of retting especially in the sample of stagnant water body 3 found 5.79 and 0.8 mgL<sup>-1</sup>, respectively. On the other hand, TDS and EC were found highest in stagnant water body 2 of 183 mgL<sup>-1</sup> and 396 μScm<sup>-1</sup>, respectively on the last day of retting. Black patches on samples collected from stagnant water bodies 1 and 2 also indicate the impact of jute retted water on jute fiber quality. Results demonstrated that jute retting deteriorates water quality as well as the quality of jute fiber. Water scarcity in different jute cultivable areas during retting time was marked for poor fiber and water quality. In ponds where aquaculture is to be attempted, it is important to take necessary measures to improve the quality of water after completing the retting process. With maintaining the water quality of jute retted water bodies farmers can use the jute retted ponds for aquaculture. Through the antiquated strategy of jute retting, it is not possible to urge the finest quality of fiber due to bacterial or fungal variables or not to preserve the stem water ratio. Improved retting by mechanized extraction of ribbon is required to apply to guarantee the quality fiber. Hence, it is vital to center on the quality evaluation of fiber by progressing the retting preparation.

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