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Cotton waste research follows the effect of pre-treatment and the observation of physical appearance

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Abstract. This paper aims to evaluate the waste cotton quality and its commercialization. The recycled cotton demand seems to be increased day by day: although the lower quality of the resulting items is the biggest barrier to cotton recycling. A thorough analysis of recycled cotton processes is therefore necessary from separation/shredding to completion. To that end, textile wastes made of pre-consumer cotton were systematically collected from the spinning mill. After pretreatment of cotton waste cellulose by caustic soda, alkali, and detergent in 100°C temperature for 30 minutes have produced white clean cotton. Following the next process by sodium hydroxide and isopropyl alcohol must produce Carboxymethyl Cellulose (CMC). CMC has big use in Textile printing, finishing, and warp sizing even in Ice-cream and food baking industry. Recent success stories will be addressed with the steady cotton processing to altering the properties of cell wall cotton and cotton fiber. The prospects of conducting experiments of waste cotton and checking the properties of treated cotton have a great value in the production of commercial products and the results relived that the value addition of waste cotton is a very easy method.

Keywords: Waste cotton; Treated Cotton; Nano-cellulose; Microcrystalline cellulose; Recycling.

1. Introduction

Environment protection and waste recycling have become two of the most important challenges facing the scientific and industrial community. The different textile processes create various waste materials in different stages such as fibre, sliver and yarn. Textile production and consumption are continually increasing. Generally, waste recycling requires accounting technical and economic considerations. Environment studies have to address these two interests and suggest solutions to persuade manufacturers to treat waste [1]. In our region, the textile industry has huge potential. The largest foreign currency earner has been raised. It spread throughout the area. In recent years, it has made a significant contribution to our GDP. This sector generates approximately 4.2 million workers. Waste management in this field has also become very important in the textile sector in Bangladesh. The recycling of textiles



also has an immense effect on our economy [2]. The demand for cotton increases day by day in the world, the traditional approach used to assess the quantity of cotton litter, which includes high volume [3]. In the textile industry, cotton is the main raw material. It accounts for around 40% of the world's total refined fibers. Many quality parameters and origins can characterize cotton. Length, maturity, strength, and elongation parameters of base cotton fibers depend on the genetic structure of the variety, the area of cultivation, i.e. the soil and the soil/environment, irrigating, or non-irrigated conditions, the harvest, and ginning. Saw ginning can do more harm to fiber than rollers [4]. Mechanical cotton processing in yarn mills results in cotton waste [5]. Waste cotton is a highly mechanical textile fiber that can be re-used in different ways. To measure the waste cotton quality a world-class testing machine is designed to calculate the mechanical properties which are used in research [6]. For analyzing cotton quality, a set of machines developed from the very beginning of the industrial period. Standardized cotton testing instruments [7] and AFIS measurements are increasingly being used to acquire quality data from cotton breeders and fiber processors as a primary and routine tool [8]. HVI machine was a great creation of science. The HVI test is a primary and regular measurement that gives cotton researchers fiber properties [9]. Afterward, there was a requirement of trash or waste cotton analysis, thereby the precondition HVI machine has developed [10]. The demand for cotton increases day by day in the world, the traditional approach used to assess the quantity of cotton litter, which includes high volume [3]. After pretreatment, there is a change of cotton fiber in regards to its physical, chemical, and mechanical structure. For example, after liquid ammonia treatment cellulose converts to cellulose-III with a much more crystalline region [11]. In this research study, to explore the quality analysis parameters of raw cotton, wastage cotton, and treated cotton.

2. Methodology

The cotton-growing region in the world has been shown in Figure 1. Only the topmost 15 countries report evaluating in this report. Many factories in the world are manufacturing a lot of goods using waste cotton as their principal raw material [12]. In a bath containing industrial scoring and bleaching agents, the cotton is first treated. In the process of scoring and bleaching cationization can easily be done in a short time when alkaline and high-temperature conditions are used. Optimal conditions of pre-treatment are as follows: griges are treated with a bathtub of 4 grams of cotton and a hydrogen detergent of 6 g/L of 30% at 90 °C for 60 min, and 30 g/L of GTA and 3 g/L of sodium hydroxide are applied for further 15-minute treatment in the bath. Bathroom condition: Tests and evaluations of fiber performances, including whiteness, water absorption, time of diffusion and capillary effect. Analysis of X-ray diffraction, the morphology of the surface and thermal analysis of cotton that has been pre-treated, are also investigated [14].

This chapter is intended to clarify the techniques and designs used in this thesis for experimental testing. The flow diagram is the project process from start to finish as shown in Figure 2. The purpose of the flow chart is to graphically show the viewers the sequence of activities in a process to make them understandable. The whole analysis methodology phase flow chart was presented, if we see below flow diagram, cotton collection from the spinning mill which cotton already going to trash after that collected sample was tested by USTER HVI-1000 same time we compare spinnable cotton fiber with waste cotton fiber in same USTER HVI-1000 AFIS model machine. There are two types of waste normally we got from spinning mill one called Dropping-1 and another called Dropping-2. Later there was a treatment by a different chemical such as Dicholoro Mythene (DCM), Sodium Hydroxide (NaOH), Peroxide(H_2O_2), and detergent the relevant output was Mono Crystalline cellulose.

2.1 Raw cotton and waste cotton source

Raw cotton and waste cotton fiber collected from different spinning as per 5% Uster Statistics. The wastage from the Carding frame is called Dopping-01, Wastage from the blow room is called Dopping-02 and the good quality raw cotton collected from the imported fiber of the same spinning mill named Multazim Spinning Mills Limited. This cotton origin from Australia Raw Cotton(E-2160) Dt:18.09.18 Supplier: Shandong Jing, L/C No-0167618230007.

2.2 Raw and waste cotton analysis

In practice, the SCI could be used as the priority to pick bales and second priority, followed by micronaire, to monitor the selection of fibres. Since the SCI has six associated properties, the SCI and micronaire can be controlled to regulate the properties of all cotton. The Equation for Regression The following is used for the estimation of the SCI [15]:

$$SCI = -414.67 + 2.9 \times \text{strength} - 9.32 \times \text{micronaire} + 49.17 \times \text{UHML} + 4.74 \times \text{UI} + 0.65 \times \text{Rd} + 0.36 \times (+b) \tag{1}$$

Where UHML is the upper half mean length in inches; UI is the uniformity index; Rd is the reflectance degree, and (+b) is the yellowness of cotton fibre. Uniformity of cotton (the distribution of cotton fiber longitude, short fiber, is an important factor in the textile industry. In the processing of cotton of a given variety in standard machinery, there is a statistically significant relation between short fiber quality (SFC) and uniformity (UI) [16].

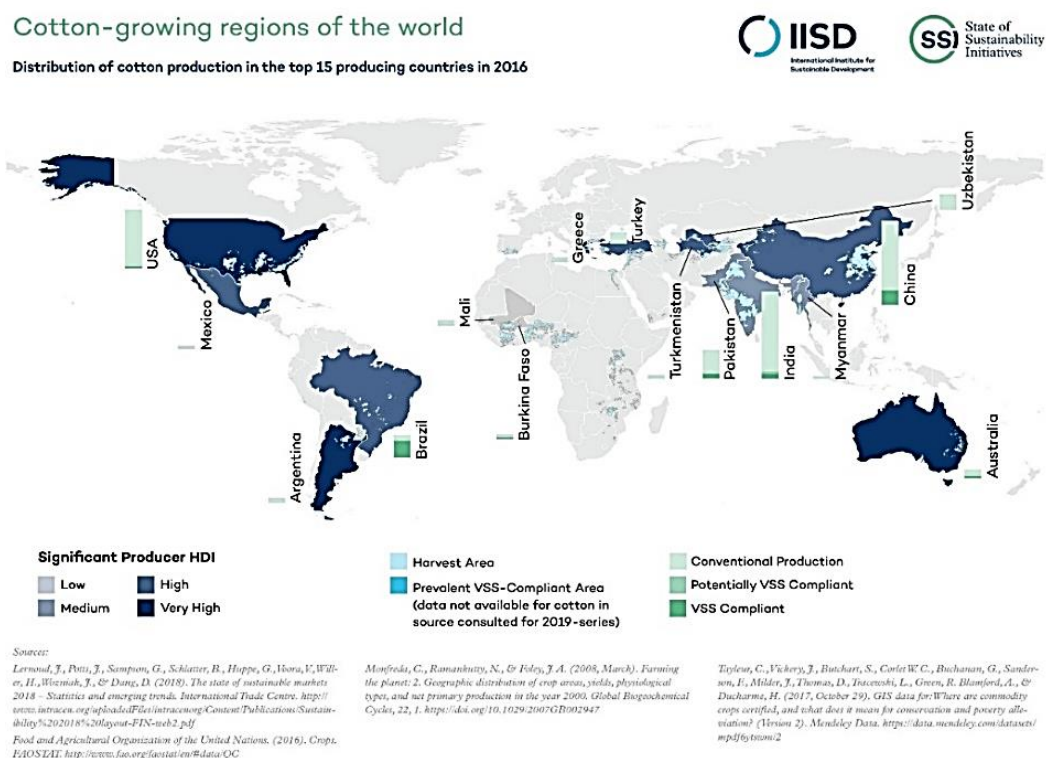


Figure 1. Map of cotton -growing countries in the world [13].

Table 1. Chemicals and sources.

Chemical	Source	Purity/Grade
Dichloromethane	Merck, Germany	99.8%
NaOH	Murali, India	98%
Sodium chloride	Fisher Chemicals, Belgium	Analytical grade
Detergent	Rheopol BMW, Uk	90%
Hydrogen Peroxide	HP chemicals, Bangladesh	50%

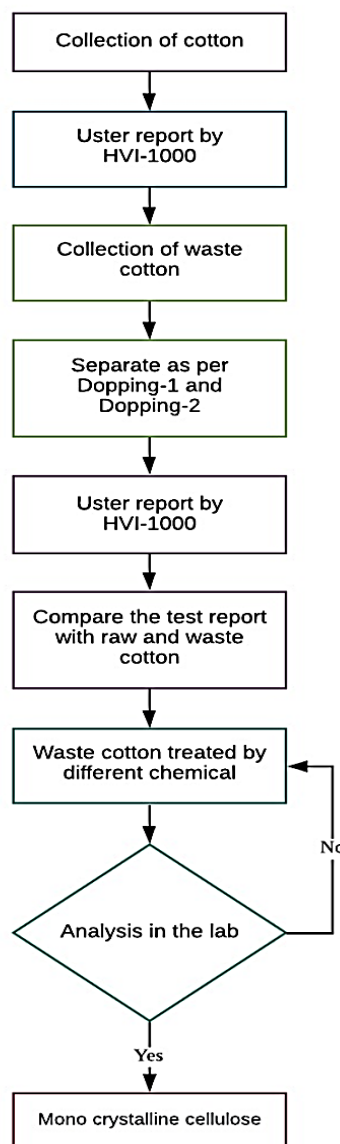


Figure 2. Process flow of preparing mono crystalline cellulose.

In order to research different manifestations and cellulose morphologies, we attempted to create a general characterization of SEM techniques. On the one hand the analysis of SEM and which simultaneously performs ensemble measures on multiple sections. On the other hand, scarce particles of a specific kind are detected, classified and fully defined by careful sample screening even in case of low concentration. [17]. After preparing CMC, Mono Crystalline Cellulose was analyzed in Carrif laboratory of University of Malaysia Pahang. The resultant images and data are spelled out below the data analysis and discussion part.

3. Result and discussion

3.1 Short fiber comparison

A cotton quality parameter is important for short fibers in a cotton sample. The efficiency of yarn production and yarn quality is impaired by shorter cotton fibers. [18]. But due to only the availability of HVI, we have used the HVI USTER statistics regression model. The waste ratio from USTER can be

regarded as a short fiber quality indicator for the fiber statistics with raw and waste fiber. Short fiber average ratio% was obtained that dropping-1, Dropping-02 and raw cotton were 17.5%, 24.8%, 8.7% consequently. CV% of dropping-1 and dropping-02 almost the same 2 and 1.8 but CV% of raw cotton was 1.3. But the standard deviation of dropping-1 and dropping-o2 was 2.8 and 0.8 whereas the standard deviation of raw cotton 1.6. In this Figure 3, it has shown that Sample-01 raw cotton short fiber percentage almost 8 but at the same time when this raw sample waste produces dropping-01 (Carding waste) short fiber percentage nineteen and dropping-02 (Blow room waste) short fiber percentage twenty-five percentages.

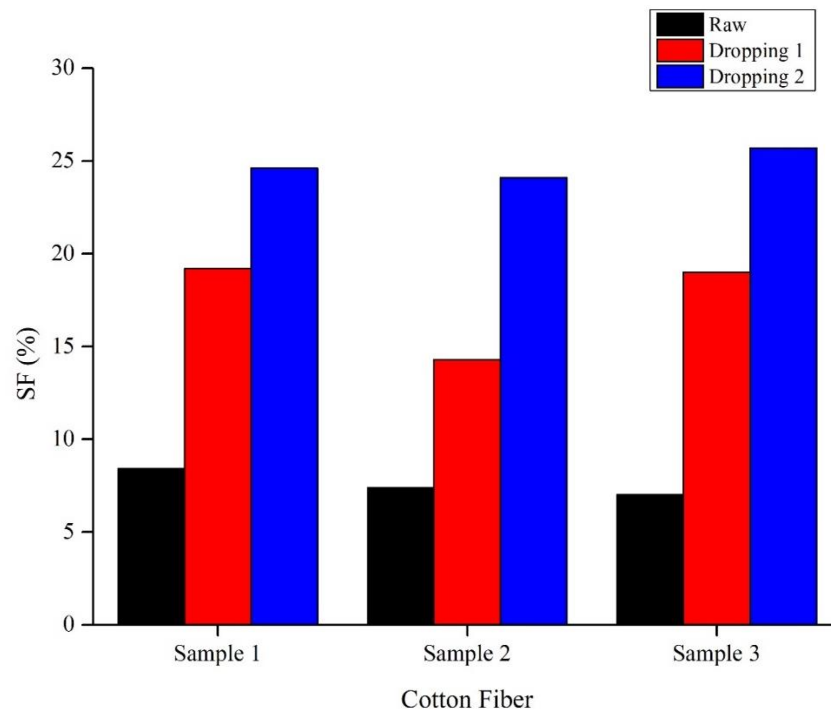


Figure 3. SF% comparison ratio of raw cotton and waste cotton (Dropping-01, Dropping-02).

3.2 Upper half mean length

The textile industry is interested in fiber quality as it is directly concerned with the production, efficiency, and quality of yarns. Fiber length is one of the most important marketing and processing properties of cotton fibers. The fiber length has a few parameters affecting production quality, the quantity of waste, fly generation, and cleaning [19]. There was a clear picture of raw cotton and waste cotton Upper Half Mean Length. Raw cotton upper UHML is on an average 30-33mm and waste cotton varies from 25-27mm. The optimal minimum upper half mean [20] fiber length in foreign markets is 28 mm. UHML is also linked to characteristics of strength and fineness, they allow increased spinning speeds. This is equivalent to increased output and lower costs per unit.

3.3 Elongation

The higher elongation fibers also developed higher yarn tensile and fewer yarn defects. Consequently, due to their less break-prone nature, the higher detent in fibers seems to improve their efficiency in spinning and other processing phases. Higher elongation would therefore ultimately increase textile products' efficiency. By the reference of journal and paper, elongation% is a must need part of cotton spinning. In Figure 5, we observed that raw cotton elongation percentage is more or less, but waste cotton fiber elongation percentage is varying from 5% to 6%.

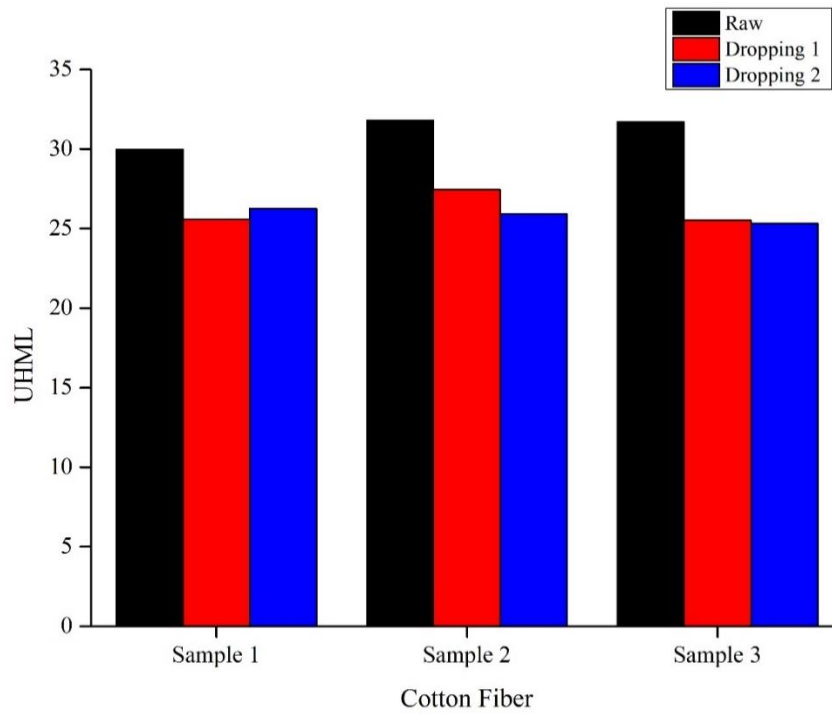


Figure 4. Upper half mean length(UHML) comparison ratio of raw cotton and waste cotton (Dropping-01, Dropping-02).

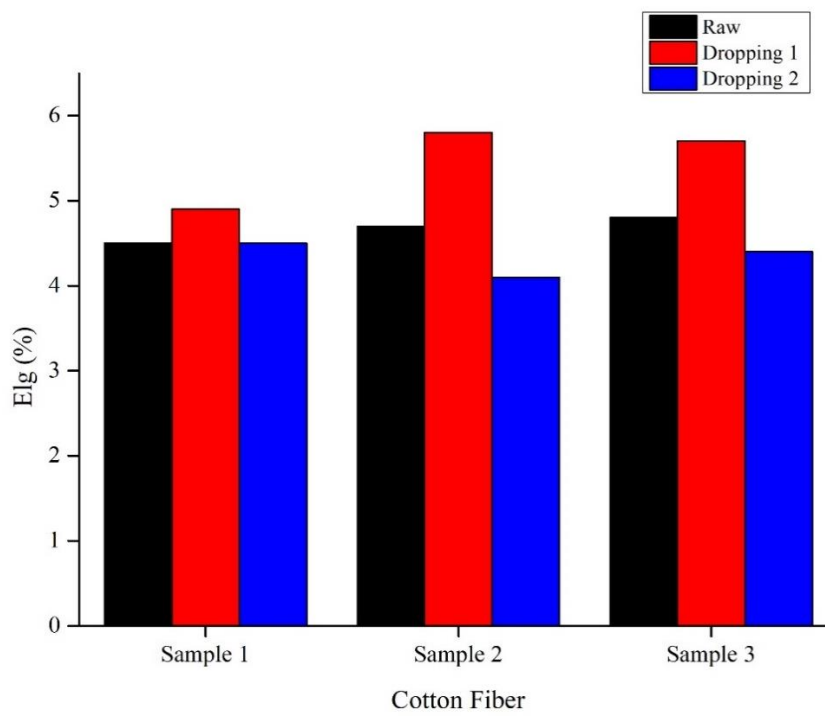


Figure 5. Elongation% (UHML) ratio of raw cotton and waste cotton (Dropping-01, Dropping-02).

3.4 Spinning Consistency Index

The spinning consistency index (SCI) serves to measure the overall strength of the cotton fiber as well as its spin ability. Most HVI measurements are used for the regression equation. In Figure 6 we have seen 11 operating points of cotton spinning. Till drawing frame and carding spinning consistency index may be floating on a different scale for example SCI was 115 to 150. Later after the drawing frame jumping 150 to 190. The fiber characteristics affect yarn characteristics. The fiber of cotton still is a very common textile industry fiber with physical properties varying depending on the growing area. Properties including fiber length, fineness, strength, and maturity influence the tensile tension of the yarn, equality, imperfection, and hairiness. SCI was the most important parameter to maintain good quality yarn [21]. If we compare Figure 6 with Figure 7, it has been shown that Figure 6 just shown the SCI value of different stages in the meantime I was measured the value of SCI of raw cotton and waste cotton. In Figure 6, sample-01 the raw cotton value of SCI is almost 140 whereas the waste cotton SCI value was 85 and 60. But is a matter of sorrow that below 110 it is very difficult to prepare or produce yarn. Sample-02 and sample-03 were showing almost the same results. In Figure 6, blow room and carding highest SCI value is 150 but in Figure 6, only raw cotton was spinnable but waste cotton was not spinnable due to low SCI value.

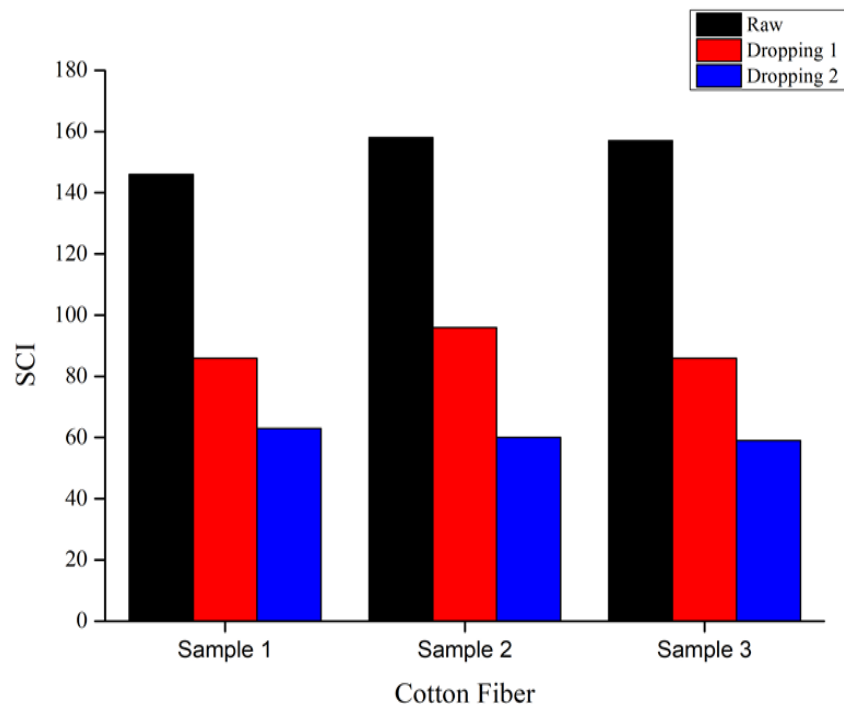


Figure 6. SCI value of raw cotton and waste cotton (Dropping-01, Dropping-02).

3.5 Micronaire value of cotton (MIC).

Buyers of cotton and textiles prefer a range of 3,8 to 4,5 Micronaire and a fiber length of 1 1/8 inch or longer. Thicker or thinner fibers cause problems in both spinning and uniform dyeing of yarn. The air permeability calculation of compressed cotton fibers is Micronaire (MIC). It is also used as a fiber fineness and maturity indication [22]. In Figure 7, we have seen that raw cotton MIC value in between 4 to 5, Dropping -01 value between 5 to 6 and at last Dropping-02 value in more than 6.

3.6 Moisture Content of Cotton

In determining cotton moisture before ginning, according to information from the USDA, the optimal moisture content for cotton is between 6.5% and 8%. When yarn dyed with this percent MC is of a higher quality than cotton is if the moisture content was substantially lower. In this Figure 8, we have

seen that raw cotton moisture in the same level most 6.2%-6.3% on the other hand waste cotton Mst% value is almost the same in samples 1 and 2 but in sample 3 the waste cotton moisture content is almost 7.

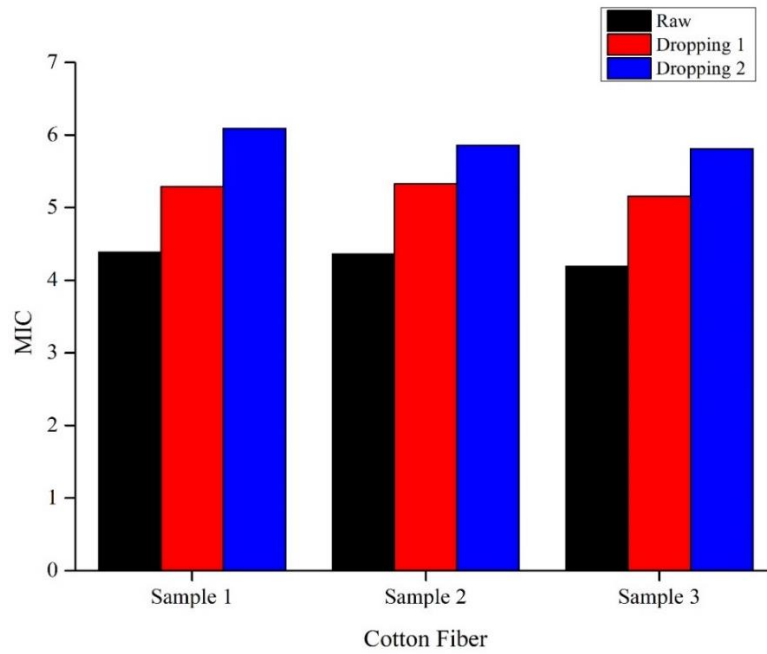


Figure 7. MIC value of raw cotton and waste cotton (Dropping-01, Dropping-02).

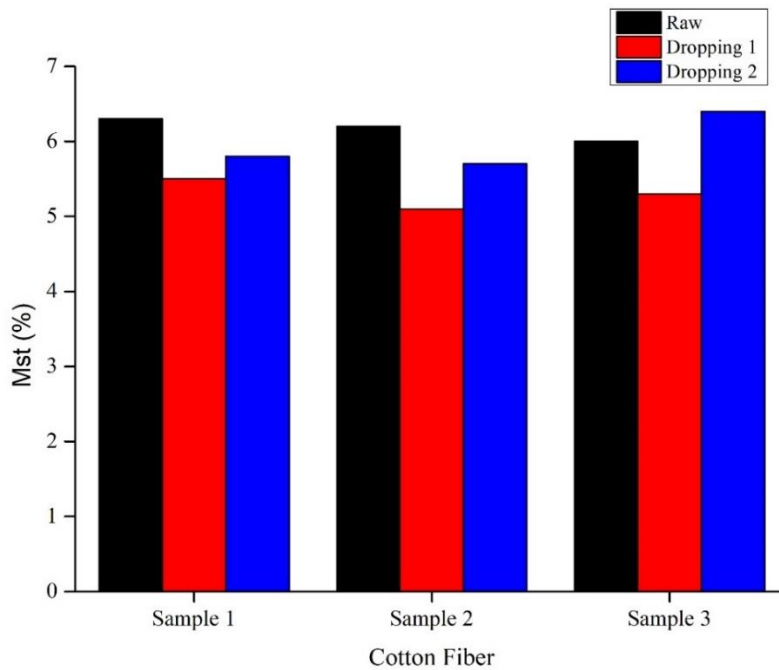


Figure 8. Moisture (Mst%) value of raw cotton and waste cotton (Dropping-01, Dropping-02).

3.7 Summary of waste and raw cotton analysis

By Uster ANOVA analysis we have analyze Spinning consistency index (SCI), Microniar value (MIC), Upper half mean length (UHML), Moisture(MS), Maturity(MAT), Uniformity Index (UI), Short fiber percentage (SF), strength (STR), elongation (EL). If we see all 3 tables, the average value of the SCI index of raw cotton is 143 at the same time average of dropping-02 and dropping-3 are 61 and 89. Moisture% is more or less the same in regards to raw and waste cotton. The average value of MIC value in raw cotton 4.62 same times in waste cotton was higher. The maturity content of all samples is almost the same varying from 0.89 to 0.92. The most important part of this table is UHML, the average UHML of dropping-02 was 25.83mm, dropping-01 was 26.18mm, these waste cotton were not used in spinning. The standard deviation of dropping-02 and dropping-01 also too high 1.8 and 1.6 on the other hand raw cotton or workable cotton UHML was 30.69mm and the standard deviation very satisfactory level 1.1. Same if we see uniformity index raw cotton UI% was higher than waste cotton. Short fiber is a curse for the spinning process if have observed in any kind of analysis that higher short fiber lower quality of cotton yarn. In analyzing average dropping-02 the short fiber content 24.8% and dropping-01 was 17.5% whereas raw cotton short fiber content was only 8.7% and the standard deviation also remarkable level only 0.9 which shows very good quality cotton. Strength% of all 3 characters of cotton were almost equal, the average value of dropping-02 was 31.5 g/tex, dropping-01 was 29.7 g/tex as well as raw cotton was 33.3g/tex which is higher than the waste cotton. Subsequently, elongation% of dropping-02 was 4.3% then dropping-01 was 5.5% and raw cotton have 4.3%. All three tables showed that the average, standard deviation, CV%, Q99%+/-, Min, and Maximum value of all parameters. The quality of the yarn is dependent on the quality and processing of the raw material. This is a reality, particularly in the current growing competition on the cotton market, leading to the use of high-performance processing equipment in spinning mills for the correct yarn quality. In spinning mills, on-line quality control, automated and integrated data processing systems and off-line quality control systems, laboratory testing systems, raw material, and yarn are also responsible for results [23]. Thereby, as a summary, we have seen the comparison of quality of raw material and waste cotton which is not useable in the spinning process.

Table 2. Resultant data of dropping-02 waste cotton.

Matam Fibre	USTE®					HVI			
System Testing - Individual Tests									
Lot ID (Dropping-02)0 Trutzschler Line/Australia									
Operator					HVI SW Version 3.2.2.15				
Print Date 19/3/2019					Serial Number 1007159				
Print Time 11.40 am					Test Method 4				
Short/Weak Reference Upland					Long/Strong ref Upland				
n	3								
	SCI	Ms [%]	Mic	Mat	UHML [mm]	UI [%]	SF [%]	Str [g/tex]	Elg [%]
Average	61	6	5.92	0.92	25.83	72.8	24.8	31.5	4.3
Std. Dev	2	0.3	0.15	0.00	0.46	1.3	0.8	1.1	0.2
CV%	3.4	5.8	2.5	0.3	1.8	1.8	3.3	3.6	4.4
Q99%+/-	12	2.0	0.85	0.01	2.63	7.5	4.7	6.5	1.1
Min	59	5.7	5.81	0.91	25.33	71.6	24.1	30.3	4.1
Max	63	6.4	6.09	0.92	26.24	74.2	25.7	32.6	4.5

Table 3. Resultant values of dropping-01 waste cotton.

Matam Fibre		USTE®					HVI			
System Testing - Individual Tests										
Lot ID (Dropping-01) Trutzschler Line/Australia										
Operator										
Print Date 19/3/2019										
1007159										
Print Time 11.33 am										
Method 4										
Short/Weak Reference Upland										
Long/Strong ref Upland										
n	3									
	SCI	Ms [%]	Mic	Mat	UHML [mm]	UI [%]	SF [%]	Str [g/tex]	Elg [%]	Rd
Average	89	5.3	5.26	0.89	26.18	77.5	17.5	29.7	5.5	69.8
Std. Dev	5	0.2	0.09	0.01	1.10	1.6	2.8	1.4	0.5	0.4
CV%	6.1	4.0	1.7	0.6	4.2	2.0	16.0	4.6	9.2	0.6
Q99%+/-	31	1.2	0.50	0.03	6.28	9.0	16.1	7.7	2.9	2.3
Min	86	5.1	5.16	0.89	25.52	76.2	14.3	28.4	4.9	69.5
Max	96	5.5	5.33	0.90	27.45	79.2	19.2	31.1	5.8	70.3

Table 4. Resultant data of raw waste cotton.

MULTAZIM SPG. MILLS LTD. UNIT-3										
USTE®										
System Testing - Individual Tests										
Australia Raw Cotton (E-2160) Dt:18.09.18; Supplier: Shandong Jinig, L/C No-016761823000										
Operator										
HVI SW Version 3.4.1.71										
Serial Number										
1512345										
Test Method 4										
Short/Weak Reference Upland 34119										
Long/Strong ref Upland 34119										
n	3									
	SCI	Ms [%]	Mic	Mat	UHML [mm]	UI [%]	SF [%]	Str [g/tex]	Elg [%]	Rd
Average	143	5.9	4.64	0.88	30.69	82.2	8.7	33.3	4.9	80.4
Std. Dev	9	0.3	0.24	0.01	0.87	1.1	0.9	1.6	0.4	1.9
CV%	6.2	5.5	5.1	0.8	2.8	1.3	10.8	4.9	7.4	2.3
Q99%+/-	1	0.0	0.01	0.00	0.05	0.1	0.1	0.1	0.0	0.1
Min	102	4.8	4.00	0.86	27.31	74.5	4.7	27.9	3.8	70.4
Max	175	7.1	6.60	0.93	38.75	86.4	12.3	40.7	6.5	83.8

3.8 Treated cotton image analysis

The fiber's morphological structures show that waste cotton and after treatment waste cotton by different chemical chemicals. Figure 9 indicates that the treated cotton fiber is relatively smooth, while the Figure 10 illustrates that its raw surface is rough. SEM images describe that waste cotton was not so much organized not sufficient crystalline region but the size of fiber was almost the same in waste and treated cotton the diameter varying $11\mu\text{m}$ - $15\mu\text{m}$. The treated cotton having more air permeability area then the waste cotton. Waste containing materials is more piled with blow room and textiles. Card waste materials have a lower degree of plundering and a higher content of short fiber but a shorter length of the fiber. Small fibers are possibly too small to render a card waste pill. Treated cotton is more organized than waste one and less short fiber. By the morphological test, we have seen that treated cotton diameter was more volatile.

It has been compared with the below images [24] than we see below images were described micro value to nano value of cotton. For further study of using these micro cotton waste fibers to nano cellulose which might be used commercially. Natural fiber is used because it is inexpensive, rich, sustainable, and biodegradable [25]. They also can be used to improve adhesives, mobile device parts, biomaterials, spumes, aerogels, and textiles [26-28]. So, at the end of the day, this waste cotton has great value if we recycled this cotton to make microcrystalline cotton and for further study to make nanocrystalline fiber. When it was waste it was very cheap but when after chemical treatment it was made a raw material of valuable nano cellulose preparation.

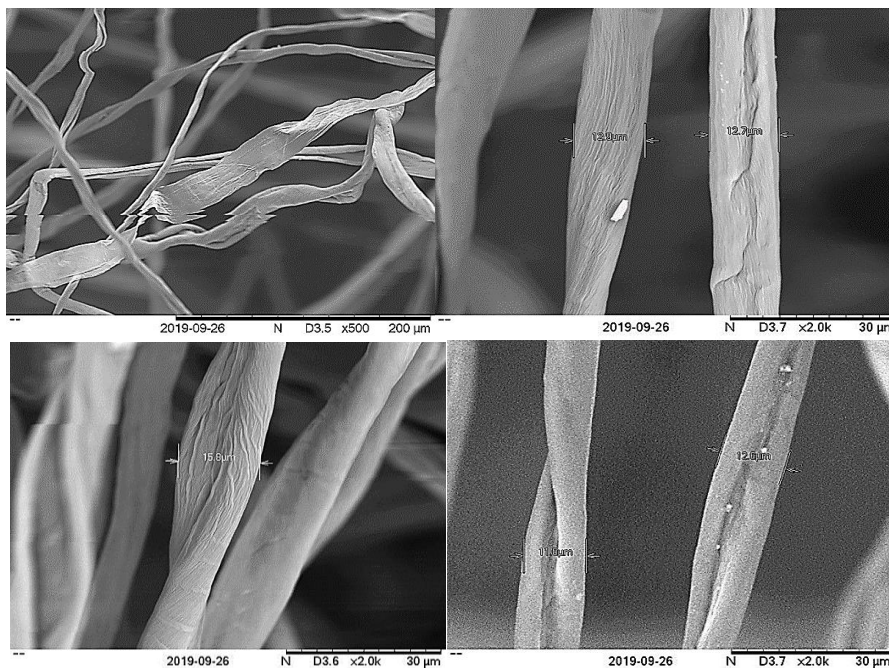


Figure 9. SEM images of waste cotton and treated cotton.

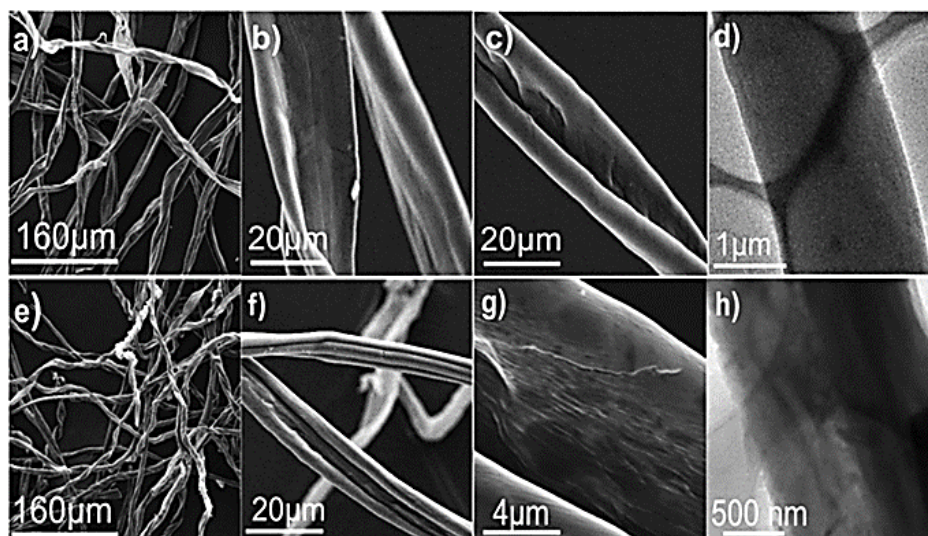


Figure 10. SEM images (a–c) and TEM image (d) of the commercial cotton; SEM images (e–g) and TEM image (h) of the NCCFs [24].

4. Conclusion

Initially, a method is built for more product developments to characterize waste and cotton treated. The Spinning Consistency Index is a measure for the prediction of cotton fiber overall quality and spinnability. Below 110 of Spinning Consistency Index cannot produce better yarn. So below this index is going to cotton waste. This process helps us to produce sustainably recycled and durable product which can also make nano thread, coated yarn, packaging material, food packaging material and so on. The crystallinity area was increased following the pre-treatment of waste cotton, a significant improvement in cotton strength. The most significant advancement is the properties of waste cotton after treatment, raising the volatile area and becoming a commercial commodity. We can thus generate a monocrystalline area and Nano-cellulose in better condition.

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