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RESEARCH ARTICLE

Recycling of cotton dust for organic farming is a pivotal replacement of chemical fertilizers by composting and its quality analysis

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ABSTRACT

Improper management of cotton dust wastes creates environmental pollution as well as different health problems. Cotton dust waste contains important nutrient elements that can meet the need for micronutrients of crop plants that will be a potential replacement of chemical fertilizers. In this study, it was to produce the cotton dust for further utilization as compost plant raw materials and analyzed and compared various parameters in different maturity days. The cotton dust was produced in compost with different combinations with different materials (cotton dust ash, rice bran, rice bran ash, Urea) by composting pit method. It was analyzed for a wide range of parameters including heavy metals and compared with standard compost parameters. The C:N ratio varies from 18:1 to 58:1 within forty days and 17:1 to 37:1 within fifty days and 17:1 to 31:1 within sixty days. The other specification such as physical condition, color, pH, N(%), P(%), K(%), S(%), were within the standard limits. Therefore, the result of the study suggested, for forty, fifty, and sixty days matured compost, samples 1,3,4,5, samples 1,2,4,5, and samples 1,2,3,5 respectively could be used in the agriculture land for cultivation to reduce the harmful effect of chemical fertilizer in the land. The cotton dust samples 2,3,4 respectively, for forty, fifty, and sixty days should be avoided for a higher value of the C:N ratio. This information could be beneficial for the practical application of cotton dust in agriculture in Bangladesh and can be a sustainable solution in textile spinning pollution.

Keywords: Cotton waste, composting, environmental pollution, waste recycling

1. INTRODUCTION

Bangladesh is an agricultural country, where industrialization is taking place in a gradually increasing phase. Alamin [1] reported that in Bangladesh the important industries are textiles, leather training, fertilizer manufacturing, sugar manufacturing, chemical, pharmaceutical, oil refining, etc. Among these, textile industries are rapidly expanding day by day. There are 394 textile spinning units are established with 9.6 mL. Spindle, 0.23 mL. Rotor and their production capacity are 2000 million Kgs and wastage generation is 20 million kgs, which are polluting the environment by their wastage [2]. The spinning waste management system is not well defined and these wastes are not commercially usable [3]. The open air is polluted by this micro dust and these wastes are using for cooking and burning. As a consequence, the users of this wastage are suffered from different lung diseases as the air is polluted by excess smoke during burning [4]. Sometimes huge amounts of these wastes are dumped in open places that pollute the environment by mixing its micro dust in the open air at a 5% probability level [5]. It is within the range of acceptable limit of the coefficient of variability which is the degree of precision with which the treatments were compared. Users of this waste are suffering from byssinosis which is an acute occupational lung disease often observed among workers exposed to cotton dust [6, 7]. Cotton dust can cause some severe respiratory responses which include chest tightness and bronchoconstriction [8].

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Exposure to cotton dust can also be the cause of non-specific respiratory symptoms, decreasing lung function, and increasing airway responsiveness [9]. The agricultural sector of Bangladesh is destroyed day by day due to the damage friability of our land, the high price of fertilizer, and the polluted environment [10]. Our farmers use more chemical fertilizer for the faster growth of crops and vegetables [11]. But they are not concerned with the hazardous effect of chemical fertilizer on land and the environment. As a result, they can get high production from their land for short time but they can damage their land for the future. Monro [12] stated chemical fertilizers provide short term results yet in the long term damage the soil, groundwater, and our health. The compost fertilizer overcomes the hazardous effect of chemical fertilizer. Compost contains a full spectrum of essential nutrients for plant growth. Although Compost is not a fertilizer, it is a growing medium when used as an amendment to existing soil intended to improve the overall fertility and tilth of the soil [13]. Compost should be analyzed for its nutrient content prior to use so that nutrient levels can be identified and the compost used in the right application [14]. A large amount of cotton spinning wastes is generated in Bangladesh due to a large number of textile industries [15]. The cotton waste contains micro-dust comprises 50-80% fiber fragments, leaf and husk fragments, 10-25 % sand and earth, and 10-25 % water-soluble materials. The high proportion of fiber fragments indicates that a large part of the micro-dust arises in the course of processing. Nearly about 40 % of the micro dust is free between the fibers and flocks, 20-30 % is loosely bound, and the remaining 20-30 % bound to the fibers it has been demonstrated by Kumar [16]. So, this is a great scope to use this unusable waste as compost and solve the spinning waste management problem and also minimize the environmental pollution from chemical fertilizer use. As well as minimize the use of chemical fertilizer and save our land and provide the compost fertilizer to the farmers at low cost and use the non-usable spinning wastes. This research work focuses on developing composting of cotton dust and its quality analysis.

Cotton can be recycled from pre-consumers (post-industrial) and post-consumer cotton waste [17]. Discarded textile products are common source for post-consumers wastes like used apparel and home textiles. During recycling process, the cotton wastes is first sorted by type and color and then processed through stripping machines that break the yarns and fabric into smaller pieces before pulling them apart into fiber [18]. Virgin cotton is often mixed with recycled cotton to improve yarn strength [19]. Since waste cotton is often already dyed, re-dyeing may not be necessary, not more than 30% recycled cotton content is used in the finished yarn or fabric. Cotton is an extremely resource-intense crop in terms of water, pesticides and insecticides, so recycled cotton can lead to significant savings of natural resources and reduce pollution from agriculture [20]. 765 m^3 (202,000 US gal) of water can be saved by one ton of cotton recycling. Two scenarios are also chosen for recycling is incineration and landfill, and subsequently, additional two cases of incineration and landfill but with applied eco-paths are considered in order to assess the environmental improvements of the process [18].

Combining recycle cotton and plastic bottles to make clothing and textiles, creating sustainable, earth-conscious products [21]. Recycled cotton can also be used in industrial settings as polishing and wiper clothes and processing of high-quality paper. Applications like seat stuffing or home and automotive insulation, cotton can be reused. Additionally, cotton waste can be made into a stronger, more durable paper than traditional wood-pulp-based paper, which may contain a high concentration of acids.

2. MATERIALS AND METHOD

2.1. Selection of factory

Since Gazipur is a large industrial area it was convenient to have an industry in the Gazipur zone. In consideration of distance from the compost plant and the availability of raw cotton waste, Gazipur will be the feasible choice. Cotton dust was collected from Matin Limited, Kashimpur, a spinning mill which is situated near Savar, Gazipur, because of only 18 Km distance from the composting plant (Fig 1).

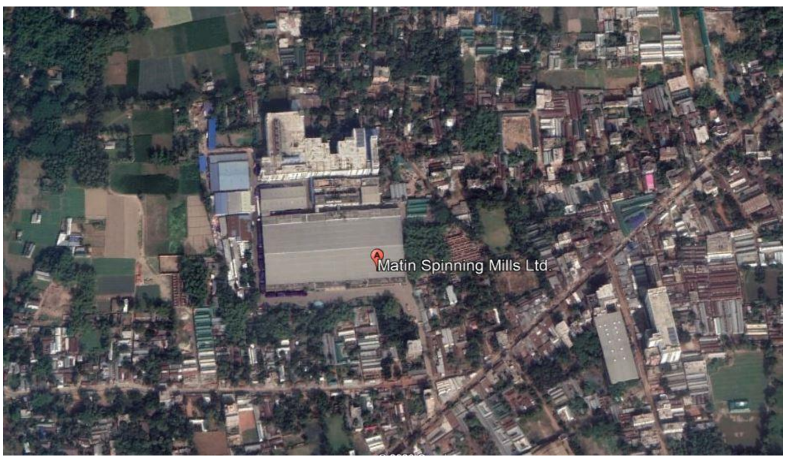

Fig 1. Location of Matin Spinning Mills Limited (Source: Google Earth)

2.2. Samples collection and preservation

120 kg of cotton dust samples were collected in four larger size plastic bags. Each bag contains 30kg cotton dust as in Fig 2, which were carried by a mini truck. To improve the quality of compost various materials were mixed with the cotton dust with a different combination, such materials as cotton spinning wastage ash, rice bran, rice bran ash, and Urea as in Fig 3.

2.3. Construction of shade on composting area

A composting shade was constructed in an open place which is shown in Fig 4. The size of the composting shade was 15'×10'. To protect the composting process from rainwater, the edge of the composting area was elevated of height 6 inches so that no rainwater comes into the shaded area.

2.4. Preparation of composting pit

For running's the composting process, composting pits were made. There were five composting pits. The size of each composting pit was 2'×2'×2' as shown in Fig 5. The longitudinal clear space between the two pits was 1.5' and the transverse clear space between the two pits was 2'.

2.5. composition of different prepared compost samples

Five samples were taken with the different ratios of cotton waste, cotton waste ash, rice bran, rice bran ash, and urea to develop the compost quality. The different combinations of composts are given in Table 1.

Fig 2. Collected cotton dust in plastic bags

Fig 3. Collection of (a) cotton dust, (b) cotton and rice bran ash, (c) rice bran and (d) urea

Fig 4. Preparation of shade on the composting area

Fig 5. Preparation of composting pit

Table 1. Different combinations of compost samples

Sample No.	Cotton spinning dust in Kg	Cotton spinning dust ash in Kg	Rice bran in Kg	Rice bran ash in Kg	Urea in kg/10kg
1	7	1.5	1	0.5	0.10
2	10	-	-	-	0.25
3	8	2	-	-	0.20
4	8	-	2	-	0.20
5	8	-	-	2	0.10

2.6. Wetting and filling of compost pit with cotton dust mixture

Before mixing all combined materials, compost materials were measured and cotton dust samples were wetted in the water in a plastic drum as displayed in Fig 6. After completing the above-identified work, the compost samples were kept in the pit by three layers, every layer was separated by using a thin soil layer and the remaining portion of the pit was filled up by earthen soil. Fig 7 shows the filling of the composting pit with the sample.

Fig 6. Wetting of the cotton dust

2.7. Remixing and moisture content check in the compost pit

For uniform composting throughout the entire height of the compost pit, the composting materials were remixed in 10 days interval. Moisture content in the compost pit was examined and kept sufficient moisture as it required standard composting of the materials according to the pit testing method recommended by Bangladesh Agricultural Research Institute (BARI), Gazipur. Fig 8 indicates the remixing and moisture content check of the composting pit.

Fig 7. Filling of compost pit with cotton dust mixture

Fig 8. Remixing and checking up of moisture content in the compost pit

2.8. Collection and drying of compost samples

For comparing the maturity and quality analysis, compost samples were collected three times from the pit First samples were collected after forty days, the second samples were collected after fifty days and finally, the samples were collected after sixty days. The sample collection procedure is shown in Fig 9. Fig 10 expresses the drying of collected samples for three days in sunlight before quality analysis.

Fig 9. Collection of samples from the compost pit

Fig 10. Drying of compost materials in sunlight

2.9. Laboratory analysis of compost

Physical condition and color were determined by eye visible condition. pH was determined by a conductivity meter (EC150, HACH). Potassium in the ash solution was determined by using a flame photometer. Available Phosphorous was determined using the Bray P1 method it has been demonstrated by Olsen and Sommers [22]. The Organic Carbon content of compost was determined using the dichromate oxidation method. Total Nitrogen was determined by the Kjeldahl distillation and titration method.

3. RESULTS & DISCUSSION

3.1. Properties of raw micro cotton waste

Table 2 represents the physical condition and chemical properties of raw cotton waste which were analyzed in the laboratory.

3.2. Properties of cotton compost for forty days

Physical, chemical, and nutrients properties of cotton compost

The physical properties of cotton dust compost with individual samples are shown in Table 3. The physical condition of samples was dust and the color is as black as standard compost. So considering these two parameters, samples were used in this study had been a good agreement to produce typical compost. The percentage of moisture of different combinations of cotton compost at forty days samples were varied between the values of 8% to 13% which were within the standard limit.

Table 4 represents the chemical properties of cotton dust compost. The pH of a different combination was varied between 6.3 to 6.9 which were within the standard limit recommended by BARI. The percentages of OC, N, and C:N ratio of cotton compost after forty days samples were varied between the values of 16 to 35, 0.6 to 0.95, and 18:1 to 58:1 respectively, while sample 2 was exceeded the recommended value in the case of OC (10-25) and C:N (maximum 20:1).

Nutrient properties of cotton dust compost are expressed in Fig 11. The percentages of P, K, and S values of all samples were varied between 0.66 to 0.85, 1.30 to 2.05, and 0.29 to 0.41 respectively where all the values are in the standard limits recommended by BARI.

Table 2. Properties of raw micro cotton waste

Specification	Raw material
Physical condition	Fiber
Color	Off white
Moisture (%)	0.121
pH	7.6
Organic carbon (OC) (%)	45
Nitrogen (N) (%)	0.58
Carbon: nitrogen (C:N)	78:1
Phosphorus (P) (%)	0.65
Potassium (K) (%)	1.25
Sulfur (S) (%)	0.2

Table 3. Physical properties of compost at forty days

Parameters	Compost Std. of BARI	Nominated Samples				
		1	2	3	4	5
Physical Condition	Non granular form	Dust	Dust	Dust	Dust	Dust
Color	Dark gray to black	Black	Black	Black	Black	Black
Moisture (%)	Maximum 15	10	12	11	13	8

Table 4. Chemical properties of compost after forty days

Parameters	Compost Std. of BARI	Nominated Samples				
		1	2	3	4	5
pH	6-8.5	6.9	6.9	6.9	6.4	6.3
OC (%)	10-25	18	35	16	18	16
N (%)	0.5-4	0.95	0.6	0.90	0.88	0.90
C:N	Maximum 20:1	19:1	58:1	18:1	20:1	18:1

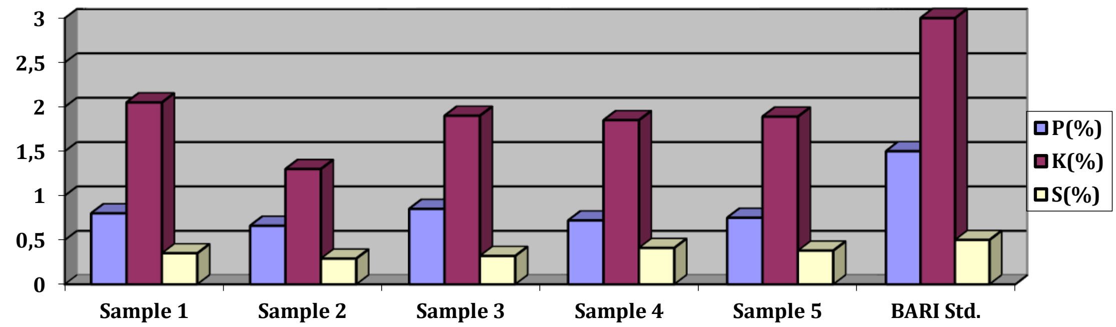

Fig 11. Nutrient properties of compost after forty days

3.3. Properties of cotton compost for fifty days

Physical, chemical, and nutrients properties of cotton compost

Table 5 indicates the physical properties of cotton dust compost after fifty days. The physical condition is dust and the color is as black as standard compost for all samples. These two parameters can be taken into consideration on the basis of using these samples to produce typical compost. The percentage values of moisture for all the samples were varied between 9% to 14% which was not exceed the standard limit.

The chemical properties of cotton dust compost are shown in Table 6. The pH and N values for all samples in case of fifty days compost were within the BARI standard limit. The percentages values of OC and C:N ratio were also within the standard limit except for sample 3, whose OC value is 33, and the C:N ratio is 37:1.

In terms of Nutrient properties of cotton dust compost after fifty days, all the P, K, and S values are within the acceptable limit for compost standard recommended by BARI which is illustrated in Fig 12.

3.4. Properties of cotton compost for sixty days

Physical, chemical, and nutrients properties of cotton compost

The percentage of moisture of different combinations of cotton compost after sixty days of samples were varied between the values of 10% to 14% which was not exceeded the acceptable limit. Besides, the physical condition and the color were also followed by the standard guidance of BARI as presented in Table 7.

Table 5. Physical properties of compost at fifty days

Parameters	Compost Std. of BARI	Nominated Samples				
		1	2	3	4	5
Physical condition	Non granular form	Dust	Dust	Dust	Dust	Dust
Color	Dark gray to black	Black	Black	Black	Black	Black
Moisture (%)	Maximum 15	11	13	14	12	9

Table 6. Chemical properties of compost after fifty days

Parameters	Compost Std. of BARI	Nominated Samples				
		1	2	3	4	5
pH	6-8.5	7.9	7.5	7.1	6.7	7.2
OC (%)	10-25	17	24	33	17	15
N %)	0.5-4	0.93	1.2	0.89	0.89	0.88
C:N	Maximum 20:1	18:1	20:1	37:1	19:1	17:1

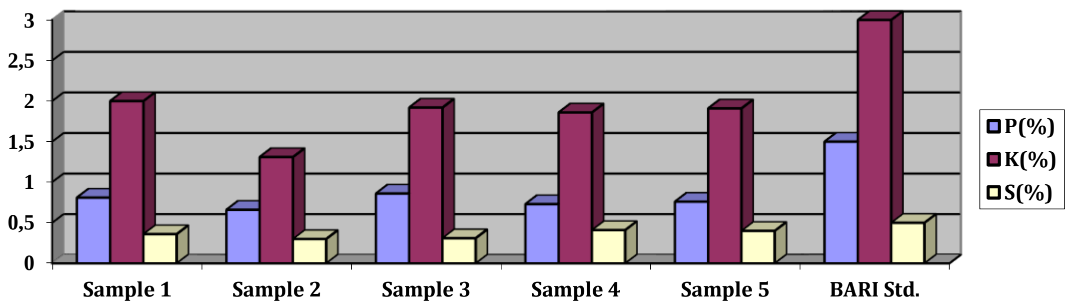

Fig 12. Nutrient properties of compost after fifty days

Table 7. Physical properties of compost at sixty days

Parameters	Compost Std. of BARI	Nominated Samples				
		1	2	3	4	5
Physical condition	Non granular form	Dust	Dust	Dust	Dust	Dust
Color	Dark gray to black	Black	Black	Black	Black	Black
Moisture (%)	Maximum 15	12	11	10	14	10

According to Table 8, the pH and N values of sixty days compost samples were varied between 6.9 to 7.7 and 0.88 to 1.23 respectively. On the contrary, the values of OC and the C:N ratio were in the acceptable limit except the sample 04 having the value out of limit.

The parameters representing the Nutrient properties of sixty days of compost samples are delineated in Fig 13. The maximum value of P, K, and S were 0.87, 2.02, 0.40 had been found in samples 3, 1, and 5 respectively whereas the minimum values of them were found in sample 2. All values of different parameters within the range of BARI guidance.

Table 8. Chemical properties of compost after sixty days

Parameters	Compost Std. of BARI	Nominated Samples				
		1	2	3	4	5
pH	6-8.5	6.9	7.3	7.4	7.7	7.4
OC (%)	10-25	17	22	24	28	15
N (%)	0.5-4	0.92	1.15	1.23	0.89	0.88
C:N	Maximum 20:1	18:1	19:1	19:1	31:1	17:1

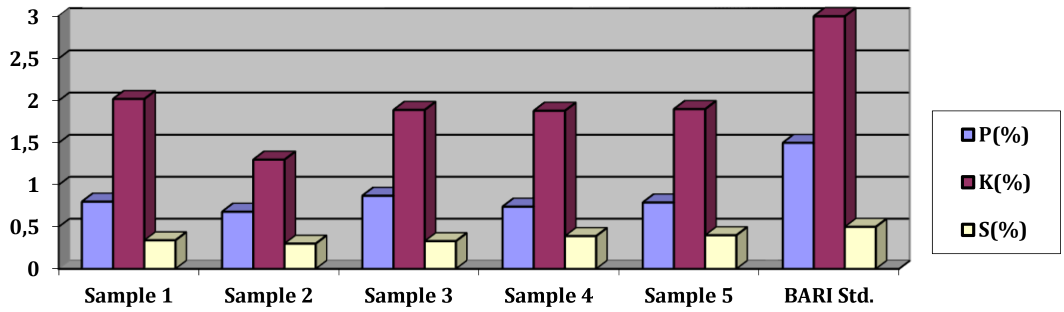

Fig 13. Nutrient properties of compost after sixty days

Optimum compost value (C: N ratio) indicates the rate of decomposition of compost mixtures and most compost is considered finished when C: N ratio is in the range of 12-22. So, in this study, sample 2 for composting after forty days, sample 3 for composting after fifty days, and sample 4 for composting after sixty days except for all other samples for different days of composting are in suitable condition for cotton dust compost. Moreover, those 3 samples have higher C: N ratio than standard values because there is not enough nitrogen for optimal growth of the microbial populations, so the compost will remain relatively cool and degradation will proceed at a slow rate.

4. CONCLUSIONS

Cotton dust compost has been produced with different combinations and compared the compost maturity with different days. The cotton dust compost has been analyzed in different maturity periods and compared different parameters with the standard value requirement of compost according to BARI, Gazipur, Bangladesh. For forty days matured compost, sample 1, sample 3, sample 4, sample 5, for fifty days matured compost, sample 1, sample 2, sample 4, sample 5 and for sixty days matured compost, sample 1, sample 2, sample 3, sample 5 could be used in the agriculture land for cultivation to reduce the harmful effect of chemical fertilizer in the land. The cotton dust sample 2 for forty days, cotton dust sample 3 for fifty days, and cotton dust sample 4 for sixty days should be avoided due to the higher value of the C:N ratio.

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REFERENCES

[1]. J. Alamin, "Report of the Board of Directors in the 29th AGM of BTMA," Dhaka, BTMA, 2012.

[2]. M. Sakamoto, T. Ahmed, S. Begum, and H. Huq, "Water pollution and the textile industry in Bangladesh: Flawed corporate practices or restrictive opportunities?," *Sustainability*, Vol. 11 (7), pp. 1951, 2019.

[3]. Y. Hu, C. Du, S.-Y. Leu, H. Jing, X. Li, and C. S. K. Lin, "Valorisation of textile waste by fungal solid state fermentation: An example of circular waste-based biorefinery," *Resources, Conservation and Recycling*, Vol. 129, pp. 27-35, 2018.

[4]. A. V. Hinson, V. K. Lokossou, V. Schlünssen, G. Agodokpessi, T. Sigsgaard, and B. Fayomi, "Cotton dust exposure and respiratory disorders among textile workers at a textile company in the southern part of Benin," *International Journal of Environmental Research and Public Health*, Vol. 13 (9), pp. 895-906, 2016.

[5]. N. Pensupa, S.-Y. Leu, Y. Hu, C. Du, H. Liu, H. Jing, H. Wang, and C.S.K. Lin, "Recent trends in sustainable textile waste recycling methods: Current situation and future prospects," *Topics in Current Chemistry*, Vol. 375 (5), pp. 76, 2017.

[6]. K. Y. Mustafa, W. Bos, and A. S. Lakha, "Byssinosis in Tanzanian textile workers," Lung, Vol. 157 (1), pp. 39-44, 1979.

[7]. S.M. Kennedy, D.C. Christiani, E.A. Eisen, D.H. Wegman, I.A. Greaves, S.A. Olenchock, T.-T. Ye, and P.-L. Lu, "Cotton dust and endotoxin exposure-response relationships in cotton textile workers," *American Review of Respiratory Disease*, Vol. 135 (1), pp. 194-200, 1987.

[8]. D.C. Christiani, T.-T. Ye, S. Zhang, D.H. Wegman, E.A. Eisen, L.A. Ryan, S.A. Olenchock, L. Pothier, and H.-L Dai, "Cotton dust and endotoxin exposure and long-term decline in lung function: results of a longitudinal study," *American Journal of Industrial Medicine*, Vol. 35 (4), pp. 321-31, 1999.

[9]. X.-R. Wang, L.-D. Pan, H.-X. Zhang, B.-X. Sun, H.-L. Dai, and D. C. Christiani, "A longitudinal observation of early pulmonary responses to cotton dust," *Occupational & Environmental Medicine,* Vol. 60 (2), pp. 115-121, 2003.

[10]. T. Chowdhury, H. Chowdhury, A. Ahmed, Y.-K. Park, P. Chowdhury, N. Hossain, and S.M. Sait, "Energy, exergy, and sustainability analyses of the agricultural sector in Bangladesh," *Sustainability*, Vol. 12 (11), pp. 4447-4462, 2020.

[11]. K. M. A. Rahman and D. Zhang, "Effects of fertilizer broadcasting on the excessive use of inorganic fertilizers and environmental sustainability," *Sustainability*, Vol. 10 (3), pp. 759-773, 2018.

[12]. Monroe. Organic Fertilizer Vs. Chemical Fertilizer - Does It Matter? [Online]. Available: Available: https://www.monroeworks.com/organic-fertilizers-vs-chemical-fertilizers.html#/

[13]. H. Schulz and B. Glaser, "Effects of biochar compared to organic and inorganic fertilizers on soil quality and plant growth in a greenhouse experiment," *Journal of Plant Nutrition and Soil Science*, Vol. 175 (3), pp. 410-422, 2012.

[14]. I. Celik, I. Ortas, and S. Kilic, "Effects of compost, mycorrhiza, manure and fertilizer on some physical properties of a Chromoxerert soil," S*oil and Tillage Research*, Vol. 78 (1), pp. 59-67, 2004.

[15]. M. T. M. Saiful Islam Tanvir, "Solid waste for knit fabric: Quantification and ratio analysis," *Journal of Environment and Earth Science*, Vol. 4 (12), pp. 68-80, 2014.

[16]. R. S. Kumar, "COTTON DUST - Impact on human health and environment in the textile industry," *Textile Magazine-Madras*, Vol. 49, pp. 55-61, 2008.

[17]. S. Asaadi et al., "Renewable High-Performance Fibers from the Chemical Recycling of Cotton Waste Utilizing an Ionic Liquid," *Chemistry-Sustainability-Energy-Materials*, Vol. 9 (22), pp. 3250-3258, 2016.

[18]. S. Yasin, N. Behary, S. Giraud, and A. Perwuelz, "In situ degradation of organophosphorus flame retardant on cellulosic fabric using advanced oxidation process: A study on degradation and characterization," *Polymer Degradation and Stability*, Vol. 126, pp. 1-8, 2016.

[19]. W. Liu, S. Liu, T. Liu, T. Liu, J. Zhang, and H. Liu, "Eco-friendly post-consumer cotton waste recycling for regenerated cellulose fibers," *Carbohydrate Polymers*, Vol. 206, pp. 141-148, 2019.

[20]. S. Kouser and M. Qaim, "Impact of Bt cotton on pesticide poisoning in smallholder agriculture: A panel data analysis," *Ecological Economics*, Vol. 70 (11), pp. 2105-2113, 2011.

[21]. L. Shen, E. Worrell, and M. K. Patel, "Open-loop recycling: A LCA case study of PET bottle-to-fibre recycling," *Resources, Conservation and Recycling*, Vol. 55 (1), pp. 34-52, 2010.

[22]. S. R. S. L. E. Olsen, Methods of soil analysis-Part 2: Chemical and Microbiological properties. (2nd edition). American Society of Agronomy, Soil Science Society of America Madison, Wisconsin USA., 1982.