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Sustainable collection development towards greener future: Earthsavers

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ABSTRACT

Nowadays, environmental awareness is more important not to damage the living environment. Sources of the Earth have been decreasing day by day due to many natural and human-induced reasons such as global warming, waste disposal, urbanization, deforestation, etc. Harm of the textile sector on the environment is high and it needs control and awareness. Raw material production, raw material selection, water usage amount, sustainability of processes, refining of wastes, recycle and reuse strategies of textile companies have a very significant effect on the environment. With this awareness, sustainable fashion is created because customer behaviors affect both design and production. In this view, all ingredients and processes turn to the most sustainable forms as much as possible. While being environmentally friendly, required performances of garments should be met to prepare the required end product. In this study, a sustainable collection whose name is Earthsavers is prepared by using recycled raw materials, natural dyestuffs, etc. Their physical and chemical performances are tested. Results of the collection are suitable for acceptance levels and it shows that a collection can be prepared with minimum harm to the environment with at least the same performances as conventional alternatives.

Keywords
sustainable,
collection,
fastness,
sustainable fashion,
recycled materials

1 Introduction

Sources of the Earth have been decreasing day by day, such as water, air, soil, land, minerals, food from plants and animals, and fossil fuels. High water usage, global warming, drought and land reclamation decrease the water sources. Discharging insufficiently refined wastewater into water sources damages the water source and causes a lacking of the source because the contaminated water supply becomes useless or harmful for consumption of all living environments. High carbon emission due to urbanization, unsuitable filters of car exhausts and plant chimneys and accumulation of greenhouse gasses cause the pollution of air, decrease the air quality and air lacking is formed as a result. Soil is damaged from disposing of waste without any control and suitable refining. Also drought is the major problem for soil to be infertile, thus many soil sources are damaged. Due to lack of soil, land and many minerals diminish. With all these negative effects on many sources of the Earth, plants and animals are existing and this provides a decrease of food from plants and animals and causes a food shortage. Lastly, fossil fuel sources which are limited are decreasing because of high consumptions in different industries and daily works. Reduction of supplies of the Earth is a problem for all living organisms to live, breath, eat, drink and be safe.

It can be clearly observed that each industry and their activities harm the Earth in different ways and at different levels, but actually each one has an adverse effect if the environmental concerns are not commonly valid. In the textile industry, nature is consumed from raw materials to the end product through all processes. For raw materials, high irrigation can decrease the water sources for producing natural fibers. Also man-made fiber production has many petroleum products and during and until the end of the production many byproduct chemicals are formed and given to the earth uncontrollably as all gas, liquid and gas. These are harmful for the environment and wastes of these petroleum product textiles can be not degradable for many years. Thus selecting sustainable production methods for natural raw materials and using less synthetic raw materials are very valuable for the environment.

The second problem for the textile industry is the high amount of process water. For a T-shirt production approximately 2700 L water are consumed and this amount is equal to enough for drinking for three years [1]. Also many chemicals which are as dyestuffs, detergents, surface active agents, finishing chemicals, etc. are used in the wet process of textile industry as washing, pretreatment, dyeing and finishing process. These chemicals can be harmful for the environment if the refining processes are not performed in detail and efficiently. At the discharge, these chemicals pollute the water supplies such as rivers, seas, oceans and underground water supplies, making them useless due to contamination. Greenpeace prepared a report on heavy metal presence in China’s rivers due to textile factories and they stated that lead, mercury, chrome, copper and cadmium metals which were coming from denim factories in the area, were detected in the examined river [1]. In addition to this some solid wastes of textile processes and waste of wastewater refining mills as biological refining mud cakes can be landfill into soil and this also causes pollution and contaminates the soil so that fertile soil turns into solid waste landfill. Deforestation causes loss of soil in nature as erosion, landslide and desertification, resulting in loss of soil. Furthermore, microplastics are released to water supplies due to high synthetic fiber uses in textile productions even at washing stages and these microplastics amount to approximately 20-35% of total microplastic level of marine habitat [2].

Carbon emission of textile production stages is also very high because the factories’ processes are very long and detailed. Many types of textile machinery are used which consume high levels of energy such as heat and electricity. These energies are supplied due to use of coal, petroleum products and natural gas. At the end of these processes, many different types of gasses are produced and released from textile plant chimneys. 10% of the greenhouse gasses is produced from textile industry and according to a report of the European Environment Agency, each person is a cause of 654 kg of carbon dioxide emission in 2017 [3].

It is obvious that the textile industry has many adverse effects on the environment with many parameters and serious precautions should be taken to save the Earth. With this point of view, more sustainable production methods should be followed at the production of natural fibers. The synthetic fiber usages should be minimized and their more environmentally friendly alternatives should be preferred in newly

designed collections. Water usage should be minimized in the wet processes and environmentally friendly processes should be designed and used widely. Hazardous chemicals should be replaced with environmentally friendly and natural options, and natural dyestuff usage should be increased. Refining processes should be increased and performed in detail under control and discharging procedure should be stricter. The wastewater that can be reused after refining processes should be reused in the other processes as process water or heating water. Landfilling should be under control, minimized and only nonhazardous and biodegradable wastes should be landfill. Solid waste should be recycled and reused as much as possible. Carbon emissions and energy usages should be decreased and renewable energy sources should be preferred such as sunlight, wind energy, etc. To increase this awareness, customers should desire the environmentally friendly garments in the collections and pay attention to the production story of their garments. Textile producers should show respect to the environment and obey the needs of innocuous production.

As a result of this respectful awareness, circular economy which includes recycle and upcycling after production and usage stages is followed instead of linear economy which is based on production, usage and disposal stages only [4]. This methodology is very valuable for sustainable strategies. To support the sustainable strategies, “Green Deal” was formed and approved in 2020. It is a policy that minimizes the harm of daily life and almost all industries such as construction, food, transportation, energy, textile, etc. and provides a more sustainable Earth. The goal of the Green Deal is to reach climate neutrality in the European Union until 2050 [5]. Thus it requires suitable raw materials, green chemicals, sustainable processes, dignity of work policy, respect to nature, recycle and reuse policies. This deal has changed the textile customer demand behaviors. Textile collections, designs and orders have changed and focus on sustainability in all steps of the products. Before the global warming, scarcities and Green Deal, most customers select their garments to protect their bodies and feel good, aesthetic and valuable. Green collections should meet the needed aesthetic and performance requirement of the customers. However, green collections have a psychological advantage compared to conventional ones. This advantage is thought of showing respect to nature and it supports sales. For example, H&M produced a “Conscious” collection that includes recycled raw materials and greener production methods. Their mottos are “provide fashion responsibility” and “use natural resources responsibility” [6]. There are some studies on psychological effects of sustainable fashion studies in the literature that support improvement of recycling and reusing [6-8]. But there is a challenge in recycling. Wastes that will be recycled are not homogenous and they are in tiny forms mostly as a mix. They must be classified before used at recycling and must be homogenized to yield good physical and chemical properties and of course good aesthetics. Thus it can be assumed as not sufficient enough, but in fact if suitable processes and combinations are selected, recycled garments can be very useful with needed performances.

In this study, a collection whose name is Earthsavers was prepared by using natural/recycled fiber content that meets the needs and performance criteria of the customer. After collection was prepared, their fastness properties, dimensional stability, and hazardous chemical content tests were performed on different units of collection to show that a collection can be prepared in a natural and sustainable way with fulfilling demanded performances. It is aimed to raise awareness about sustainable development in the textile sector, to create the necessary knowledge and experience infrastructure in the sector and to contribute to the protection of the environment.

2 Materials and methods

2.1 Materials

Cotton, recycled wool, recycled polyester, recycled cotton and recycled polyamide are used as the main fiber content of the fabrics in the collection. Knitted and woven fabrics are used.

2.2 Methods

As presented in Fig. 1, firstly, design ideas and customer needs were evaluated. In this study, the design idea was environmental awareness and the customer needs were the needs of the Earth. Secondly, an

inspiration was found for the collection as respect to nature and natural and sustainable garments. Thirdly, design ideas were sketched. Then ideas were focused and designs were improved. After that recycled and natural fabrics were selected for the collection and the colors of the collection were selected to simulate the harmony of nature such as green, ecru, brown, blue, etc. After material and color selection, silhouette assessments were done for all components of the collection. Furthermore, sample garments and prototypes were produced.

When the prototypes were accepted, garment production was started. Layout plan was prepared according to models and sizes. Spreading was applied and fabrics were cut. Cut garment pieces were sewn (Fig. 2). Pigment printing of brand name and logos as well as accessory attachment steps were carried out in the last part of the production process. Last but not least, produced garments were tested for fitting, physical and chemical tests. Details on standard test methods as well as acceptance conditions are individually stated in Results and Discussion section.

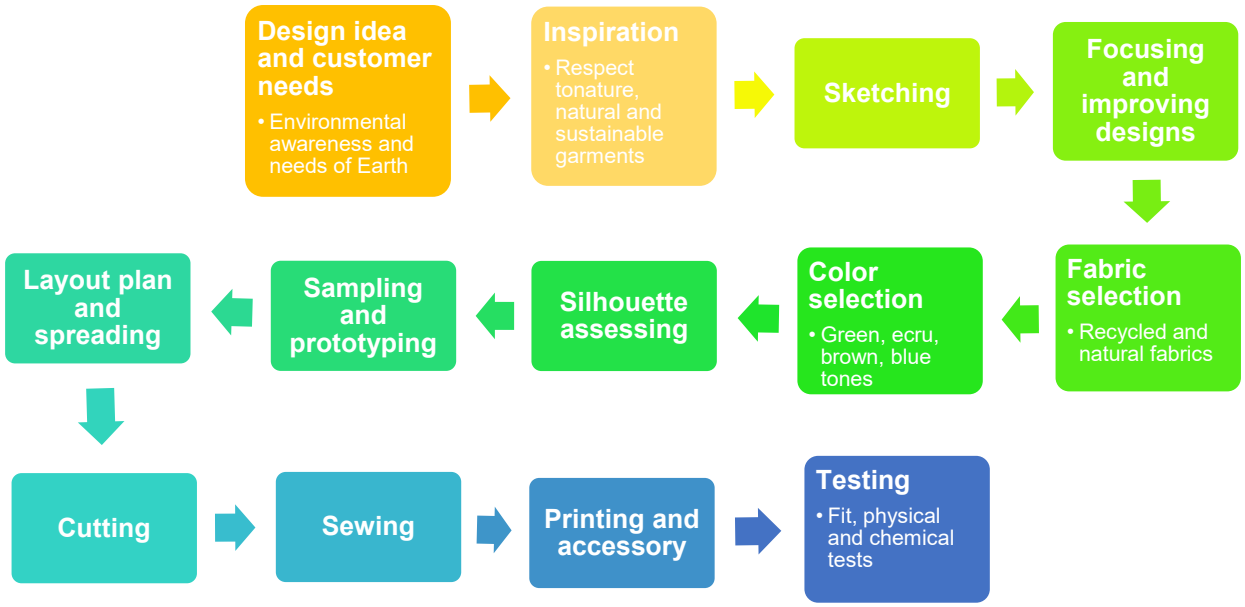

Fig. 1 Fashion design steps for the collection "Earthsavers".

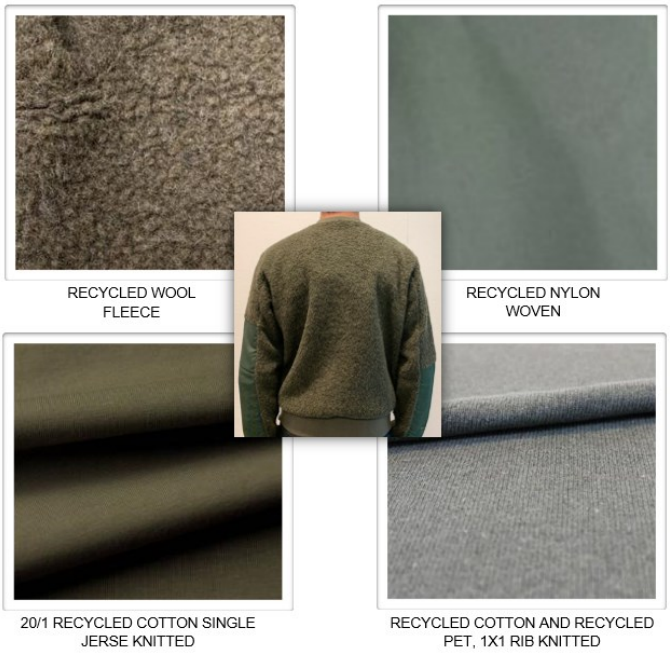

Fig. 2 Sample garment and its recycled fabrics.

3 Results and discussions

Six different samples from this collection were selected and tested for their physical and chemical performances. These samples include different types of garments such as three different T-shirts, a sweatshirt, jogger pants and a fleece. Their details such as sample names, garment types, fiber contents, constructions and colors are given in the Table . Dimensional stability test, spirality test and fastness for rubbing, water, perspiration, washing, non-chlorine bleach and light tests were performed for this study. All tests were performed according to their specific standards. Dimensional stability and spirality results are given as percentage of change. Color fastness tests are evaluated according to gray scale and score from 1 to 5 where 1 refers to the worst results (maximum staining or color change) and 5 refers to the best results, except light fastness because it is evaluated according to blue scale and score from 1 to 5 where 1 is the worst and 5 is the best color change performance.

Table 1. Samples in this study and their properties.

Sample Name	Garment Type	Fiber Content	Construction	Color
A	T-shirt	100% recycled cotton	*Yarn Count: 20/1 *Single jersey knitted fabric *Reactive dyed	Ecru
B	Sweatshirt	100% recycled cotton	*3-thread knitted fabric *Reactive dyed	Khaki
C	Jogger pants	3-Thread: 100% cotton Ripstop: 100% recycled nylon	*3-thread knitted fabric *Ripstop woven (2.55 mm fiber proof) *Reactive dyed	Black
D	T-shirt	100% recycled cotton	*Yarn Count: 20/1 *Single jersey knitted fabric *Reactive dyed	Dark cheddar
E	Fleece	*Knitted fleece: 57% recycled wool, 43% polyester *Woven fabric: 100% recycled nylon *Knitted 1x1 rib fabric: 50% recycled polyester, 49% recycled cotton, 1% elastane	*Knitted fleece *Woven/twill fabric *Knitted 1x1 rib fabric *Reactive dyed	Black
F	T-shirt	100% recycled cotton	*Single jersey knitted fabric *Reactive dyed	Black

3.1 Rubbing fastness test

Rubbing fastness tests were performed on all samples according to ISO 105-X12 standard. According to the results in Table 2, dry rubbing fastness results for color staining of all samples are 4/5 which is in the acceptance range. In case of wet rubbing, results of sample A and E are 4/5 and result of B is 3/4, and these three samples are valid for usage because they are in the acceptance range. It shows that recycled raw materials meet the needs of dry rubbing fastness test. However, results of C, D and E are rejected and these results are the only rejection this study. It can be evaluated as recycled raw materials can have little problem with wet fastness in case of dark colors.

Table 3. Rubbing fastness test results for color staining as dry and wet.

Sample Name	Dry Rubbing	Acceptance (Min 4)	Wet Rubbing	Acceptance (Min 3)
A	4/5	✓	4/5	✓
B	4/5	✓	3/4	✓
C	4/5	✓	2/3	x
D	4/5	✓	2/3	x
E	4/5	✓	4/5	✓
F	4/5	✓	2	x

3.2 Dimensional stability and spirality tests

Dimensional stability test of the samples was conducted in accordance with ISO 5077, ISO 3759 and ISO 6330, while spirality test of the samples was done based on ISO 16322-3. Dimensional stability and spirality test results are given in Table 3. Dimensional stability results changes between -0.49 and -1.8%, and these results are in the acceptance range. Minus sign indicates shrinkage of the samples. In case of spirality test, there is no spirality observed on all samples. These results prove that recycled raw materials meet the needs of dimensional stability and spirality tests. These tests were not performed on Sample E because they are based on washing stages, and Sample E is suitable only for dry-cleaning due to design, thus there is no need for any washing test on the sample.

Table 3. Dimensional stability and spirality test results.

Sample Name	Dimensional stability (%)	Acceptance (+2%, -5%)	Spirality (%)	Acceptance (Max 5%)
A	-1.8	✓	0	✓
B	-1.14	✓	0	✓
C	-1.56	✓	0	✓
D	-0.49	✓	0	✓

3.3 Color fastness to washing

Color fastness to washing test was done according to ISO 105 C06 standard and results are given in Table 4. Color change values of all samples are 4 which provides minimum accepted value. In case of staining, all components of multifiber for all samples have 4/5 value except stain on nylon of Sample C which is 3/4. All of them are suitable for acceptance, thus these recycled raw materials meet the needs of washing fastness test. This test was not performed on Sample E because the test is based on washing stages and Sample E is suitable for only dry-cleaning due to design of it thus there is no need for any washing test on the sample.

Table 4. Color fastness to washing test results.

Sample Name	Color change (min 4)	Stain on Acetate (min 3/4)	Stain on Cotton (min 3/4)	Stain on Nylon (min 3/4)	Stain on Polyester (min 3/4)	Stain on Acrylic (min 3/4)	Stain on Wool (min 3/4)
A	4	4/5	4/5	4/5	4/5	4/5	4/5
B	4	4/5	4/5	4/5	4/5	4/5	4/5
C	4	4/5	4/5	3/4	4/5	4/5	4/5
D	4	4/5	4/5	4/5	4/5	4/5	4/5

3.4 Color fastness to water

Table 5. Color fastness to water test results.

Sample Name	Color change (min 4)	Stain on Acetate (min 3/4)	Stain on Cotton (min 3/4)	Stain on Nylon (min 3/4)	Stain on Polyester (min 3/4)	Stain on Acrylic (min 3/4)	Stain on Wool (min 3/4)
A	4/5	4/5	4/5	3/4	4/5	4/5	4/5
B	4/5	4/5	4/5	4/5	4/5	4/5	4/5
C	4/5	4/5	4	3/4	4/5	4/5	4/5
D	4/5	4/5	4/5	4/5	4/5	4/5	4/5
E	4/5	4/5	4/5	4/5	4/5	4/5	4/5
F	4/5	4/5	4/5	4/5	4/5	4/5	4/5

Color fastness to water test was performed on all samples according to ISO 105 E01 standard. According to results in Table, color change values of all samples are 4/5 and it is more than minimum accepted value. In case of staining, all components of multifiber for all samples have 4/5 value except stain on cotton of Sample C which is 4 and stain on nylon of Sample A and C which are 3/4 but all of them are still suitable for acceptance and recycled raw materials meets the needs of water fastness test.

3.5 Color fastness to perspiration

Color fastness to perspiration test was performed on all samples according to ISO 105 E04 standard. Acidic perspiration fastness results are given in Table 6. Sample D, E and F have 4/5 values for both color stain of all fiber types and color change. The color change values of Sample A and B are 4 while C has 4/5. In case of staining, all other components of multifiber for remaining samples have 4/5 value except stain on cotton of Sample C with stain on nylon of Sample B which are 4 and stain on nylon of Sample A and C which are 3/4 but all of them are still suitable for acceptance.

Table 6. Color fastness to acidic perspiration test results.

Sample Name	Color change (min 4)	Stain on Acetate (min 3/4)	Stain on Cotton (min 3/4)	Stain on Nylon (min 3/4)	Stain on Polyester (min 3/4)	Stain on Acrylic (min 3/4)	Stain on Wool (min 3/4)
A	4	4/5	4/5	3/4	4/5	4/5	4/5
B	4	4/5	4/5	4	4/5	4/5	4/5
C	4/5	4/5	4	3/4	4/5	4/5	4/5
D	4/5	4/5	4/5	4/5	4/5	4/5	4/5
E	4/5	4/5	4/5	4/5	4/5	4/5	4/5
F	4/5	4/5	4/5	4/5	4/5	4/5	4/5

Table 7. Color fastness to alkaline perspiration test results.

Sample Name	Color change (min 4)	Stain on Acetate (min 3/4)	Stain on Cotton (min 3/4)	Stain on Nylon (min 3/4)	Stain on Polyester (min 3/4)	Stain on Acrylic (min 3/4)	Stain on Wool (min 3/4)
A	4	4/5	4/5	4	4/5	4/5	4/5
B	4	4/5	4/5	4/5	4/5	4/5	4/5
C	4/5	4/5	3/4	3/4	4/5	4/5	4/5
D	4	4/5	4/5	4/5	4/5	4/5	4/5
E	4/5	4/5	4/5	4/5	4/5	4/5	4/5
F	4/5	4/5	4	4/5	4/5	4/5	4/5

Alkaline perspiration fastness results are given in Table. All samples have 4/5 value for both color stain on acetate, polyester, acrylic and wool of all fiber types and color change. The color change values of Sample A, B and D are 4 while C, E and F have 4/5. Stain on cotton of Sample F and stain on nylon of Sample A are 4 while stain on cotton and nylon of Sample C are 3/4. Remaining values of stain on cotton and nylon are 4/5. It is obvious that all of them are still suitable for acceptance and recycled raw materials meet the needs of perspiration tests.

3.6 Color fastness to non-chlorine bleach and color fastness to light

Color fastness to non-chlorine bleach test of the samples was conducted in accordance with soak test method while color fastness to light test of the samples was done based on ISO 105 B02. Color fastness to non-chlorine bleach and color fastness to light test results are given in Table 8. Minimum bleach fastness is 4 of all samples and these results are in the acceptance range. In case of light fastness, test 4 value is yielded for all samples. This results approves that recycled raw materials meet the needs of color fastness to non-chlorine bleach and light tests.

Table 1: Results for color fastness to non-chlorine bleach and light

Sample Name	Color fastness to non chlorine bleach	Acceptance (min 4)	Color Fastness to Light	Acceptance (min 4)
A	4/5	✓	4	✓
B	4	✓	4	✓
C	4	✓	4	✓
D	4/5	✓	4	✓
E	4	✓	4	✓

3.7 Other tests for chemical content

All samples were tested for aromatic amines from Azo dyes (ISO 14362-1), aromatic amine salts (ISO 14362-1), NPEO and OPEO content (ISO 18254-1: Textiles), formaldehyde (EN ISO 14184-1) and phthalates (GAFTI Modified CPSC-CH-C1001-09.4). There is no sample that has any of the mentioned chemicals. Also lead content of metal and non-metal components of the garments were evaluated and there is no lead observed in any of the samples. As a result, if suitable processes and chemicals were selected in production, recycled raw materials can be used without including any harmful chemicals.

3.8 Fit test

All samples were tested for their dimensions by using a measuring tape to observe the fit of each sample. All measured samples were selected as medium (M) size and dimensions are given in centimeter (cm). Center front length, chest, sleeve length, sleeve width, neck width, shoulder, top waistband and neck drop were measured for top samples while hip, inseam and bottom waistband were measured for pant samples. Fit test results are given in Table 9. According to these results, all samples provide the required dimensions and pass the fit test.

Table 9. Dimension results of all samples at Fit Test in cm.

	Tolerance	Samples	A	B	C	D	E	F
Center Front Length	±0.6	Required	65.5	60.5		64	62	64
		Measured	65.3	60.6		64	62.3	64
Chest	±0.9	Required	59	65		66	64	66
		Measured	58.9	65.2		66	64.2	66.1
Sleeve length	±0.9	Required	21.4	50		23.5	69	23.5
		Measured	21.3	50.2		23.4	69.2	23.6
Sleeve width	±0.6	Required	22.6	27		24.2	23	24.2
		Measured	22.4	27.1		24.1	23	24.3
Neck Width	±0.6	Required	16.2	15		16.3	14.8	16.3
		Measured	16	15.2		16.4	14.8	16.3
Shoulder	±0.9	Required	74.6	70		73.5	72	73.5
		Measured	74.3	70.1		73.7	71.9	73.6
Top Waistband	±0.9	Required	66	59.5		66	61	66
		Measured	66.1	59.7		66.1	60.9	66.1
Neck Drop	±0.3	Required	3.5	4.2		4		4
		Measured	3.5	4.2		4.1		4.1
Hip	±1.9	Required			59.1			
		Measured			59.3			
Inseam	±0.6	Required			64.2			
		Measured			64.4			
Bottom Waistband	±1.9	Required			43.5			
		Measured			43.5			
		Comment	**pass**	**pass**	**pass**	**pass**	**pass**	**pass**

4 Conclusions

With global warming, urbanization and uncontrolled consuming of sources cause lacking of valuable sources of the Earth as water, air, soil, land, minerals, food from plants and animals, and fossil fuels. To rise an awareness for saving the environment, a collection whose name is Earthsavers was designed in this study with recycled raw materials. Six different garments are manufactured, namely 3 T-shirts, a fleece, a sweatshirt and jogger pants. Physical and chemical tests were performed as dimensional stability, spirality, fastnesses for rubbing, washing, water, perspiration, non-chlorine bleach and light and chemical content test. Almost all results show that recycled raw materials meet the expectation of customers and textile sector. This means that similar collections can be prepared by using recycled materials while decreasing the waste amount and showing respect to the Earth, its supplies, all living and nonliving environment.

Author Contributions

T. Güven: conceptualization, methodology, investigation, design, visualization, supervision, project administration; B. Akarsu: conceptualization, methodology, investigation, design, visualization; E. Sudaşdemir: conceptualization, investigation, design, visualization; E. Emekdar: investigation, formal analysis, data curation, visualization, writing – original draft preparation; H. Açıkgöz-Tufan: supervision, writing – review and editing; U.K. Şahin: supervision, writing – review and editing; S. Kurşun Bahadır: supervision, writing – review and editing.

All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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