



## Research Article

# Sustainability Through Textiles Recycling: Yarn Reuse, Environmental and Human Health Impact

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## SUSTAINABILITY THROUGH TEXTILES RECYCLING: YARN REUSE, ENVIRONMENTAL AND HUMAN HEALTH IMPACT

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**ABSTRACT:** For the sake of achieving the goals of economic growth and welfare increase, world resources are consumed recklessly and cause the generation of very high amounts of waste. This imbalance, consisting of production and consumption phases, has caused the ecosystem to be negatively affected. Although the waste recycling sector is an important sector in Turkey, additional studies are needed to ensure social awareness on waste management, research and development studies, and conversion of textile waste into high value-added products. A significant part of the waste in Turkey is used in yarn production. In this study; A research was conducted on the recycling processes of cotton yarn waste in a business for sustainability. Breaking strength values of yarns containing 10-50% waste in 3 different yarn counts, namely Ne 10, Ne 20 and Ne 30, were estimated by fuzzy logic modeling and the effects of textile waste on the environment and human health were examined.

**Keywords:** Textile, Yarn, Recycling, Environmental, Human health.

### 1. INTRODUCTION

Aishwariya et al., with the increase in population in the world, consumption and therefore environmental problems are increasing [1]. Avelar et al., in this context, environmental hazards and especially recycling of many types of products and materials are studied[2].

Béchir et al., the production processes of textile products are different from each other and require quite long processes [3]. Brooks et al., inputs such as raw materials, intermediate products or auxiliary chemicals used, energy type, and machinery used in each production process are very different from each other [4]. Eser, et al., the production processes of a textile product obtained using artificial fibers and a textile product obtained using natural fibers, or a colored printed textile product created by the non-woven surface method and a woven fabric with embroidery on it, are very different from each other [5]. Hassaan et al., and Hasanzadeh et al., it is very difficult to evaluate the recycling issue in textile products under a single heading, since the raw materials, machinery, energy types and costs used during production, environmental interactions occurring in the processes and the recycling potential of the products are not the same [6-7].

In a study, Hu et al., developed environmental performance indicators for waste. Sandina et al., thanks to these indicators, it is possible to evaluate the technology used for production and the

activities in production, and it is possible to evaluate environmental performance, select environmentally friendly methods and make comparisons between them [8-9]. In a study, Woolridge examined the textile recycling process in England. As a result of the study, it was emphasized that products obtained from recycled textile waste can be produced with less energy [10]. Mishra recommended it to examine the environmental damages and pollution that occur in textile production processes [11]. Rana investigated the environmental and social evaluation of ready-made clothing manufacturing and the carbon footprint effects of textile and clothing products [12]. In the study of Vadicherla, Koo, Uyanık et al. Yarn breaking strength is higher than recycled samples. Vadicherla et al. investigated the effect of blend ratio on the quality properties of recycled polyester/cotton blended ring yarn [13-15]. As a result of the literature research, research on the recycling processes of cotton yarn waste attracts attention. When the literature is examined, it is noteworthy that there is a deficiency in estimating the breaking strength values of recycled yarns from cotton yarn waste. For this reason, in this study, unlike the literature, a research was conducted on the recycling processes of cotton yarn waste. Predicting the breaking strength values of yarns containing 10-50% waste using fuzzy logic modeling was examined.

Evaluations on yarn production and estimations of breaking strength values were made for products that can be used in different areas and obtained from cotton, which is a renewable plant. In this study, it is aimed to estimate the effect of recycling cotton yarn waste and the recycled fiber ratio on the breaking strength of the yarn using fuzzy logic functions and to examine its environmental and health effects.

## **2. MATERIAL AND METHODS**

The fuzzy logic tables created in this study were described using the MATLAB program and the resulting data were examined. The Mamdani method allows us to define expertise in a more intuitive, more human-like way . At the same time, fuzzy logic is rule-based to produce an information output. These rules consist of propositions such as “If... Then... (If...Then...)” [16-20]. In the study, the type of membership functions used in the input sets is the gbellmf method, and the type of membership functions used in the output sets is the trimmf method, thus the trapezoid shape, which is a geometric shape, is obtained. Input membership functions, Yarn number (Ne), were chosen to be three feet, Waste (%) was chosen to be six feet, and output membership functions, breaking strength, were chosen to be sixteen feet. It was created with a hundred and thirty rule base in order to understand the effect of the relationship between the determined membership functions on the result [21-24].

### **2.1. Recycling of Yarn Waste**

Reuse of textile waste can be achieved in different ways. The option to save resources in waste management is recycling. Recycling textile waste means breaking down the textile product and using its components for new products [25]. Closed-loop recycling of textiles involves collecting post-consumer waste and producing fiber from these wastes to be used in new yarn production [26-27]. In order to recover fibers from textile wastes and use them in conventional textile processes in the future, the wastes must be opened and separated into fibers. In this study, bobbins, weaving beams, etc. in enterprises. The stages of transforming waste yarns into fibers through recycling were examined.



**Figure 1.** Washing process

In Figure 1, the waste yarns thrown into the boiler are first washed at 100 degrees for 30 minutes.



**Figure 2.** Crimping process

In Figure 2, after the washing process, it is subjected to a spinning process at 7500 rpm for 15 minutes to remove the water on it.



**Figure 3.** Drying process

In Figure 3, the yarn waste, from which the liquid has been removed after the squeezing process, is subjected to drying at 90 degrees for 40 minutes to remove the moisture on it.

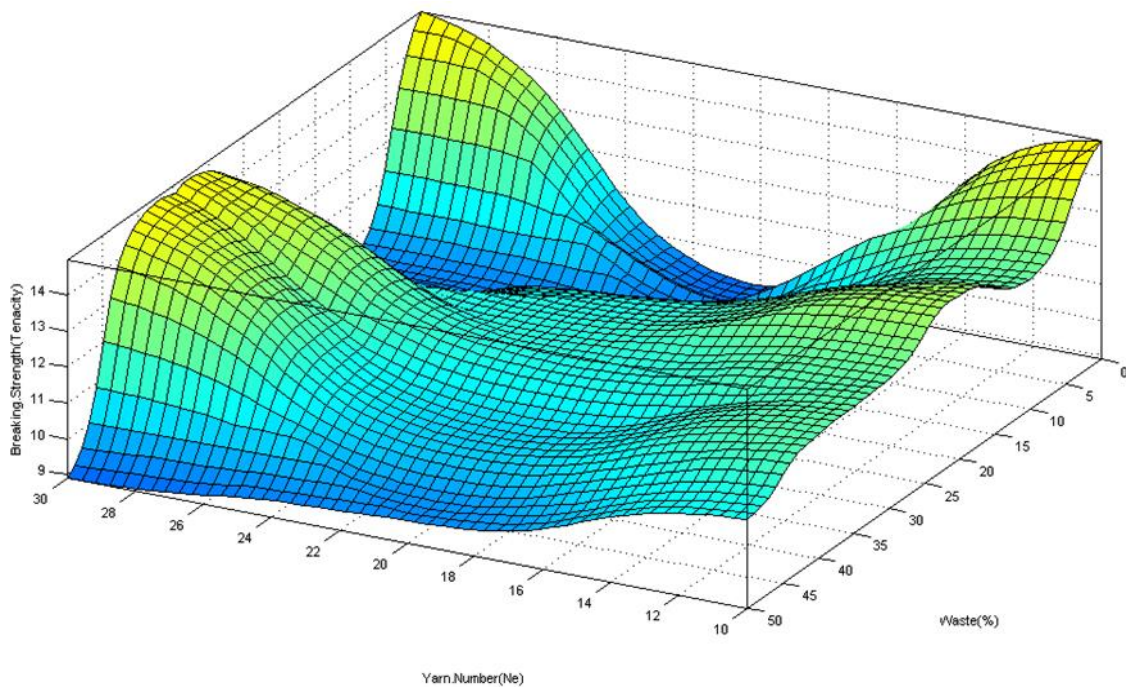


**Figure 4.** Carding process [26]

As shown in Figure 4, after the washing, centrifuge and drying processes, the fibers may remain united depending on the end use of the fiber. Then, the fibers are cleaned and mixed by the carding process, and the opened fibers for subsequent weaving or knitting processes are converted into yarns by ring, rotor and friction spinning processes.

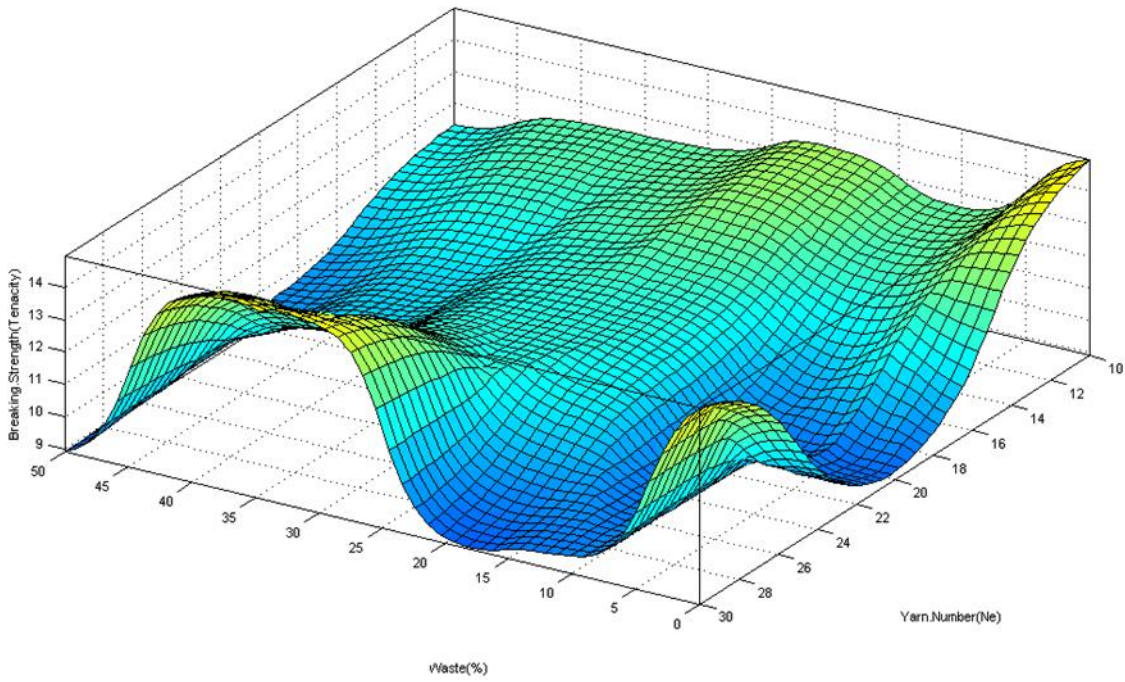
### 3. RESULTS AND DISCUSSIONS

Figure 5 shows the connection between breaking strength (tenacity cN/tex), waste and yarn number of the Matlap model created.



(a)

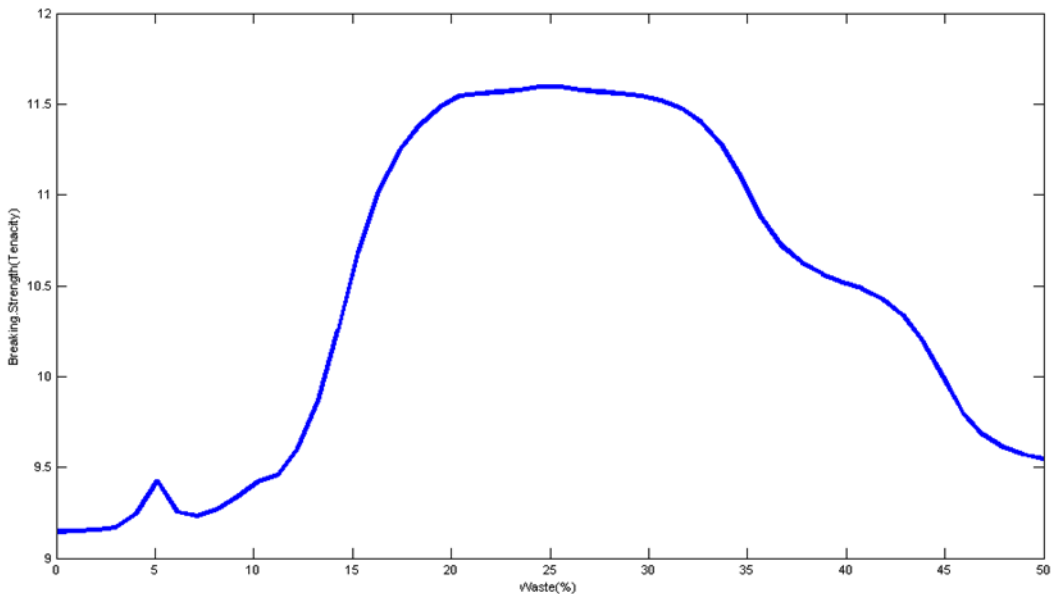




(b)

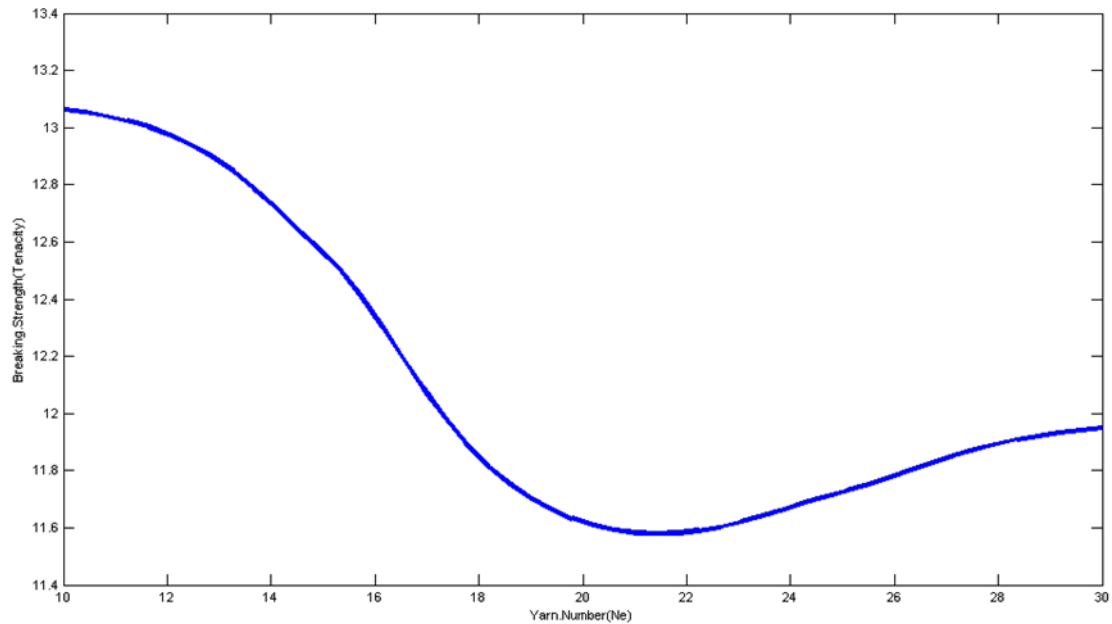
**Figure 5.** The connection between breaking strength, waste and yarn number of the created matlab model (a,b)

While the breaking strength is highest for Ne 10 yarns when the waste rate is 0%, it is seen that breaking strength decreases as the waste rate increases and the yarn with the highest waste rate (50%) has the lowest breaking strength value. In Ne 20 yarns, the yarns with the highest (100%) cotton content and (0%) waste rate have the lowest strength values, while in Ne 30 yarns, the yarns containing 25% waste have the highest breaking strength values.



**Figure 6.** Relationship between waste rate and breaking strength

Figure 6. The connection between waste rate and breaking strength is given. When the waste rate and breaking strength are compared, regardless of the yarn count, the waste rate has the highest breaking strength value between 20-30%.



**Figure 7.** Relationship between breaking strength and yarn number

The relationship between breaking strength and yarn number is given in Figure 7. When the breaking strength and yarn number, independent of the waste rate, are compared, it is seen that Ne 10 has the highest breaking strength value, while Ne 20-22 has the lowest breaking strength value.

#### **4. EFFECTS OF TEXTILE WASTE ON THE ENVIRONMENT AND HUMAN HEALTH**

The wastes generated during production and after use are considered cleaner in the textile industry compared to other industries. Cotton fiber, the most used among natural fibers, is a biodegradable raw material. However, during its production, large amounts of artificial fertilizers, pesticides and water are required and groundwater is polluted. In regions where cotton production is intense, the use of excessive amounts of pesticides negatively affects the health of living things and humans. With recycling, the amount of pesticides, artificial fertilizers and water that must be used in cotton production can be prevented. Fertilizers used in cotton production are generally nitrogen-based, and significant amounts of nitrogen leak into water resources and cause their pollution. Thanks to recycling, these negative effects will decrease or disappear completely. Lung diseases caused by dust generated during cotton ginning, emissions generated during cotton transportation, environmental effects and ecological problems of vegetal waste generated during harvest can also be reduced by recycling in this way [28].

It is possible to talk about many parameters that affect human and living health. Therefore, by taking a holistic approach, it can be said that demographic, economic, psychological, social factors and the conditions of the physical, chemical and biological environment are effective in the individual's living space [29].

In recent years, resource consumption such as water, energy and chemicals used within the scope of industrial activities seriously threaten human health and living space. In particular, emissions of some chemical substances have serious effects on human health. For this reason, toxicity evaluations of chemical substances are carried out. In these evaluations, the effects on

human health are determined by taking into account air, water and air quality rules, tolerable daily intake for human toxicity and acceptable daily intake concentrations [9].

## 5. CONCLUSIONS

The textile industry is one of the largest sectors in the world in terms of both manpower usage and consumption potential. In the process from production to use and recovery of textile products, many solid and liquid wastes, whether recyclable or not, are generated and interaction with the environment occurs. In the study, it was determined that cotton fiber, which is considered environmentally friendly as it is a natural fiber, causes many negative effects in terms of the environment.

Waste control should be addressed in textile enterprises and optimum conditions should be provided. Wastes should be classified, collected and evaluated. The product diversity and usage areas obtained from textile recycling need to be developed. The orientation of textile production towards newly developed clean technologies can be achieved by more effective and less use of natural resources and, more generally, by changing textile production and consumption models. Companies that will produce recycled products need to create important technical data infrastructures and create an inventory of production efficiency and waste loss amounts through lot tracking throughout the production processes of products obtained from waste. This situation offers significant advantages to the recycling industry. The yarn count whose breaking strength is least affected by the waste content is Ne 10. The breaking strength of Ne 10 yarns decreased with the increase in waste rate.

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