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Perceptions Towards Fabrics Production from Recycled Plastic Water Bottles in Oman, Survey Study

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Abstract: ***Enormous amounts of plastic bottles waste are a threat to the environment. These can be recycled to useful and high-demand products. A questionnaire was distributed to the residents in Oman to estimate the number of plastic bottles produced per week, disposal method, and environmental problems, public support for recycling and buying fabrics made from plastic bottles. A total of 343 participants answered the survey. About 73.7% of participants preferred to drink bottled water. Most of them (75%) dispose the plastic water bottles in the garbage. Vast majority of respondents (97.6%) believed that these bottles can affect the environment and 68.2% respondents agreed they can cause animals' death and environmental pollution. Moreover, it was found that 81.92%, 86.30% and 89.21% of participants were aware about possibility of recycling, the need of recycling in Oman and saving the energy, respectively. More than half of respondents (58%) suggested that bags collected from homes are the best way for collection. Moreover, the majority of respondents prefer to convert plastic bottles to fabrics (66.5%). Mostly female stated that they used fabrics especially for Abayas and dresses. In addition, it was calculated that the number of plastic bottles produced per week is about 3612 which can produce 8074.08 meters of fabrics yearly, therefore covering 50% of the population's need. Finally, recycling plastic bottles will enrich the economy and help in protecting the environment.***

Keywords: Recycling, Water bottles, Fabric, PET

1. Introduction

The consumption of bottled water has an obvious environmental impact, starting from plastic accumulation in the landfills and oceans to the generated pollution through its manufacturing and distribution process. Almost 700 years is required to degrade or convert plastic into fine particles [1]. This is an alarming rate posing huge risk to the environment [1]. Therefore, recycling plastic bottles is the best for protecting and cleaning the environment. At the same time, recycling plastic bottles can increase the economy of the country by producing secondary products such as pillows stuffing, strapping materials, carpet fibres, bags, and fibre for yarn [1].

There are different methods of making recycled polyester including mechanical method and chemical method. The first method recycles the plastic bottoles mechanically through polyester smelting and then extruded to produce yarn. The chemical method treats polyesterby separating it into its molecular components. It is then converted into threads that carry the same features of the original fabric, such as texture and strength [2]. The chemical method has several drawbacks, including the requirement of large areas, great energy and continuous supply and demand [3]. More than 50, 000 tons per year of high-capacity recycling lines are needed for cost efficiency. To provide a "consistent and continuous" supply of waste, bottles and other polyester waste has to travel, sometimes long distances, to reach the recycling site. This becomes an economical and ecological liability especially with the increase in the prices of baled bottles. It is very expensive, and it is almost never done to remove the various blocks of building, known as depolymerization, thus, they can be reassembled (a method known as repolymerization). Mechanical recycling is the most used recycling method. The recycling process starts from the moment the water bottles are collected and taken to a recycling facility where the process of transformation of waste into wearable fabric begins. First, via a floatation and separation technique, the bottle labels and caps are removed. This is important because plastics of various characteristics are typically made of caps and labels. Afterwards, the plastic bottles are crushed into chips, known as flakes. These flakes are then washed and melted; from this melted material, the yarn is pulled. This provides a raw material that is clean, precious, and recycled and ideal for the textile sector. Then the raw filament yarns are spun and gradually woven into a different number of fabrics [2], [4]. A good market value for the fabric can be produced by recycling plastic bottles. This can be by adding different features such as fabric breathability, moisture control and auto cleaning [4]. Several techniques have been applied to improve fabric quality. First, the use of nanotechnology to add self-cleaning property. This will make fabrics more repellent to water. This will also not allow water and dust to attach to the fabric, instead of that it will roll over and keep the fabric clean [4]. Special wicking techniques and multi-channel or tetra channel cross-section fibre design are used to make the fabric softer to the skin. This is because it becomes 200000 times flexible than the traditional fabric which will lead to reducing friction with the skin and irritation. This technique can also regulate the temperature because it provides a thin fibre, which will increase vaporization [4].

The percentage of plastic waste per year produced in Oman is around 12% in 2009 readings [4]. That is maybe because people prefer using plastic bottled water more. After all, in some areas tap water is unsuitable for drinking so the population prefers the bottled water [4]. Several studies support that producing rPET takes 33% to 53% less energy than producing virgin polyester [2]. Add to this, recycling one plastic bottle will save the equivalent to 3 hours of energy from a 60W light bulb. Moreover, greenhouse gas emission can be reduced to 71%. On the other hand, the recycled polyethylene terephthalate produces a lightweight fabric when compare it with other fabrics. Therefore, the weight will reduce the transport and storage costs [4]. Add to this, the recycled polyethylene terephthalate needs 90% less amount of water than virgin polyester. For example, producing 2kg of rPET will offer enough drinking water for a person at least for 5 days. It was estimated that 24 gallons of water are used to produce 1 pound of plastic. On the other hand, 101 gallons of water is used for producing 1 pound of cotton or wool. So, "it takes 1.85 gallons of water to manufacture the plastic for the bottle in the average commercial bottle of water" [4], which is still less than the amount of water that enters in producing wool and cotton.

The first company that starts to recycle plastic bottles into fabric in 1978 is Wellman, Inc., a US company situated in Fort Mill, South Carolina. In 1993, Patagonia, a California-based clothing corporation, started manufacturing rPET fabrics from recycled plastic soda bottles [4]. Teijin, a Japanese corporation, has recently collaborated with the company to develop its own closed-loop polyester recycling system. In the recent past, the Nike Company created a sensation by creating the kit of India's Team for the 2015 World Cup from 33 plastic bottles; cricketers' jersies were crafted from 15 recycled plastic bottles, and their pants were made from 18 such bottles. Eco- fi (formerly known as Eco Spun) is a high-quality polyester fiber manufactured from recycled plastic bottles of soda pop bottles produced by Wellman Inc. in the United States. REPREVE yarn, spun from plastic bottles, was created by the Greensboro, North Carolina-based company Unifi. Anything from T-shirts and jackets to dress pants is made with REPREVE yarn [2].Fabrics produced using reused plastic are currently getting more popular which is being made by companies, for example, EcoSimple, Marks & Spencer, and Armani Jeans [2]. Since 1995, the first eco-project of Armani has started by developing a process to recycle denim. In addition, the Eco Simple's fabrics are a mixture of reused cotton and recycled PET bottles. Furthermore, Levi Strauss which is famous for its jeans, recycles about eight PET bottles to make one pair of jeans [2]. However, there are some companies that have gone somewhat farther, they are using recycled ocean plastic and utilized fishing nets and turning them into clothes rather than using plastic water bottles [2]. Adidas and H&M are the most famous examples of these companies. Starting with Adidas, which collaborates with the ocean conservation group, Parley for the Oceans, has lately launched a swimwear line made of rPET ocean waste and fishing nets. Similarly, H&M which is a Swedish clothing company and known to be one of the biggest users of recycled polyester in the world, created an elaborate pleated gown from a sustainable material BIONIC®, which is a recycled polyester made from plastic shoreline waste, as part of its Customer Exclusive Campaign in February 2017 [2].

In Oman, there are some recycling plastic industries such as in concrete blocks as well as sustainable building material [6], [7].

According to the literature review and our best knowledge, there is no detailed study about production of fabrics from recycled plastic bottles in Oman. This study will focus on a survey study about recycling plastic bottles and convert it into useful fabrics that can be used for different applications. This will allow calculating the economical possible fabric production based on the usage of bottled water.

2. Methodology

Large numbers of plastic products that are utilized daily. Drinking bottles are made from polyethylene terephthalate (PET), which are the most convenient packaging material due its food safe, lightweight, strength, inexpensive price, transparent colour and fully recyclability. This is a survey study to estimate the number of produced plastic bottles per week. The survey was done in Google form and due to COVID 19 pandemic; it was distributed in social media platforms such as Twitter, Instagram, and WhatsApp. The distribution started in May, 2021 for two weeks and the total number of participants reached was 343. The questionnaire was divided into six sections. The first section is about respondent's characteristics. The second is detailing the drinking water preferences of the respondents. Third and fourth parts are checking the awareness and knowledge of people about the environmental problems and recycling. The fifth section is revealing the acceptance of people towards fabrics from plastic bottles and the last section is showing peoples' preferences towards empty plastic bottles collection. The information was compiled and analyzed in MS Excel 2016 spread sheet.

National Association for PET Container Resources (NAPCOR) reported that 30 of one-liter plastic bottle is needed for producing three meters of fabric [4]. In this study the number of fabrics in meters that can be produced from recycling plastic bottles will be measured by calculating the number of bottles used per year following similar method as [4].

3. Results and Discussion

3.1 Survey respondent characteristics

A total of 343 participants from Oman were answered the survey, females represented most of the respondents (69.4 %), while males accounted for just 30.6 %. The variation between the male and female in answering the survey could be understood as females were more interested in this topic. The characteristic of respondents is summarized in **Table 1**.

Table 1: Distribution of respondents by gender

Gender	Total out of 343
Female	238
Male	105
Grand Total	343

3.2 Drinking Water Preferences

Participants were asked about the preference to drink bottled water, groundwater, treated water or falaj water. **Figure 1** reveals the type of the water that people prefer to drink, 9.91% of the people prefer to drink treated water, while 16.03% of them think that groundwater is the best type of water for drinking. The vast majority, 73.76% of the participants like bottled water as a drinking water which is the highest percentage between all the water types. In addition, a very small percentage of respondents prefer to drink from the falaj water, and their percentage is about 0.29%.

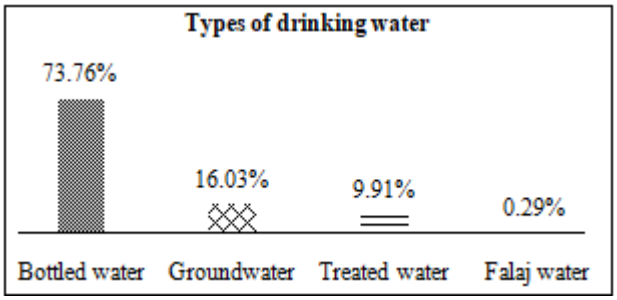

Figure 1: Types of drinking water preferred by participants

Figure 2 shows the reasons of preferring to drink from bottled water. Some participants selected more than one reason. A number of 131 selected bottled water because they found that it is easy to carry. About 146 and 148 of people believe that PET water bottles are safe and available in most of the shops, respectively. While vast majority of respondents of 225 preferred to drink from bottled water because of its cleanliness, whereas the lowest number was 103 said it is affordable. Oman is a very hot country. For this reason, people need to have water with them everywhere. Plastic bottles lightness, availability, cleanness, and their cheap price can be a justification for the selection of bottled water.

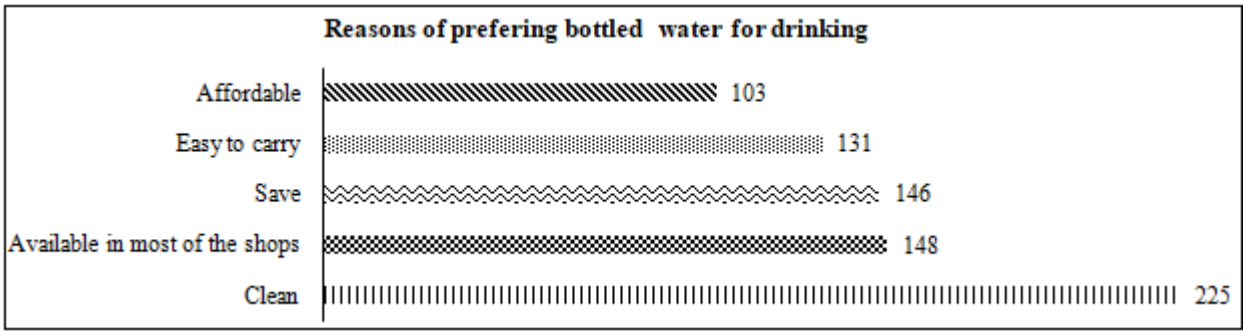

Figure 2: Reasons for using bottled water as drinking water

Table 2 shows that most participants are drinking between 6-15 plastic bottles in one week who are 44.61%. A total of 34.11% of people prefer to drink more than 15 bottles on a week. And 16.91% drink 1-15 bottles. People vary according to the bottle size of the water they prefer. The lowest percentage is 4.96 % prefer the size of 2 liter. And 15.16% like to drink in a bottle with 150 ml size. The highest percentage of people thinks 250ml of the bottle size is more suitable.

Table 1: Consumption and size of plastic water bottles per week

Consumption of plastic bottles	Total out of 343	Percentage %
1 L	39	11.37%
150 ml	52	15.16%
2 L	17	4.96%
250 ml	126	36.73%
500 ml	109	31.78%
Grand Total	343	100.00%
Consumption of plastic bottles	Total out of 343	Percentage %
0*	15	4.37%
Between 1 to 5	58	16.91%
Between 6 to 15	153	44.61%
More than 15	117	34.11%

*Drinking different water type

This survey was compared to the results of other studies conducted in Singapore, Hong Kong, and Macau, university students. The preference of students for bottled water versus filtered tap water was specifically evaluated. (13.44%) of

respondents drinking bottled water more than tap water in Singapore [8]. While, in Hong Kong and Macau (24.76%) and (24.35%), it has been noticed that consumed bottled water higher than that of Singapore, respectively. The reasons for their preference for bottled water were also studied, they said it is safe, clean, and available which are similar to the reasons of the respondent from this study [8]. According to questioner was done at the University of the Basque Country, the majority of respondents (50.2%) said they had not used a plastic bottle during the week, while around (33%) reported that they are drinking one or two plastic bottled waters in a week. Roughly (13%) and (4%) of respondents said they had consumed from 3 to 5 bottles and more than 6 bottles, respectively, during the week [9]. However, larger numbers of bottles were consumed in Oman. It may be due to the weather, as the weather in Oman is very hot; they need to drink large amounts of bottled water.

3.3 Awareness of environmental issues

The awareness of the society about the environmental problems that can be due to the use of the large amounts of plastic bottle was investigated. **Figure 3** illustrates the results of the questions that were asked to the public to investigate the awareness of people about the effect of PET plastic bottles on the environment, vast majority of respondents (97.6%) in first question believe that plastic bottled water can affect the environment. However, only 2.3% of respondents did not think that plastic bottled water can affect the environment. This was followed by another question which written in similar way, but instead of writing the environment, it is replaced by living organisms to check the understanding of people. It has been noticed that 95.34% of respondents answered yes, while only 4.66% answered no, which means that most of the respondents understood the purpose of the question. The correlation between the answers of the two questions was calculated using correlation coefficient equation using excel and it shown that it is equal to 0.424. This indicates that most of the participants selected the same answers in same questions; only 3.8% of them changed their answers to yes.

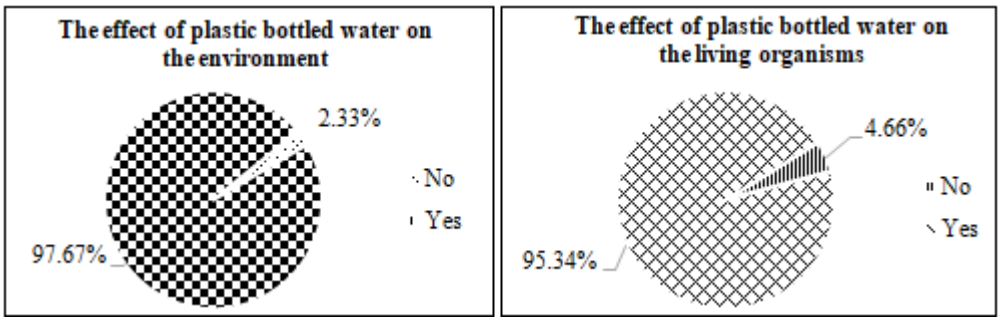

Figure 3: Effect of plastic water bottles

Among the 343 surveyed, 95 respondents believed that PET bottles can cause environmental pollution, while about 13 and 1 respondent perceive that plastic bottled water can cause animal death and respiratory impairment, respectively. In addition, 234 respondents believed that PET bottles can cause all the effects that were mentioned which are animals' death, environmental pollution, and respiratory impairment as shown in **Figure 4**. Moreover, some respondents added that PET bottles remain in the environment and takes long time to degrade and can also affect tourism due to the distortion of the natural beauty of the environment caused by plastic bottle wastes. Furthermore, other respondents were added additional effects that they aware of such as poisoning, cancer, global warming, soil problems, and blockage of sewage systems.

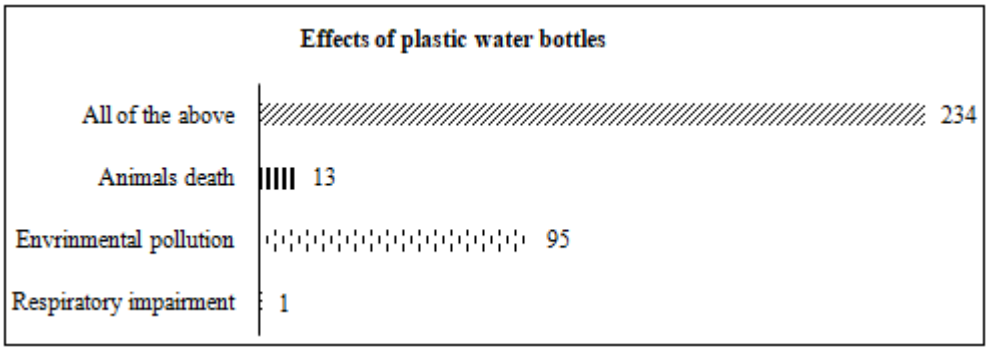

Figure 4: Problems associated with plastic water bottles wastes

The above results indicate the awareness of the population of different problems associated with the use of plastic water bottles. However, it is proved from different research that plastic wastes are toxic pollutants and cause harmful effects to the environment and human health in many ways, directly or indirectly [10]. For instance, pollution of soil, air, and water as well as death of plants and animals and serious health impacts on human [10]. According to a questionnaire done in Bangladesh, most of the participants (32%), (29%) and (23%) think that human health problems, blockage of

sewage systems and deterioration of natural beauty of environment, respectively are happened due to plastic waste [11], which agrees with the percentage found in this study.

3.4 Public support for recycling

The methods of disposing used plastic bottles were inspected. The data were collected from the contributors who do us plastic water bottles to find how they disposed them. It was found that around 75.22% of respondents place them in the garbage, while 24.78% re-use the bottles for other purposes.

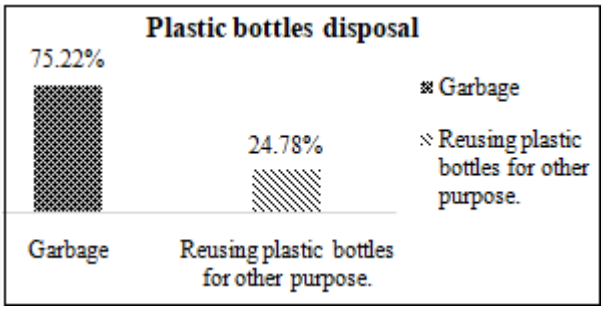

Figure 5: Plastic bottles disposal

Similar study was done in the Ohio State University; US (2018) showed that 7.9% of the respondents place the bottles in the trash while 7.6% reuse them for something else. However, large majority of population (70%) recycle them in recycling bins [12]. The availability of recycling pins in front of homes, roads, shopping centres and all other organization is required in Oman to recycle plastics and increase the recycling plastics.

Table 3 shows the questions that were asked to the participants to investigate their awareness and knowledge about recycling. Out of 343 surveyed, large number of respondents (81.92%) believes that it is possible to recycle plastic bottles, whereas 16.03% are not sure and 2.04% did not aware about the possibility of recycling. Moreover, this was followed by another question which is about the need of recycling plastic water bottles in Oman and 86.30% of participants were agree that Oman needs to recycle plastic bottles, while 12.45% were not sure and 1.17% did not think that Oman needs to recycle PET water bottles. Furthermore, participants were asked if recycling can save energy. It is shown in the results that most of respondents (89.21%) aware about the ability of recycling in saving the energy. However, about 10.79% of respondents were not aware about this.

Table 3: Responses of some question

Questions		*Percentage%*
Do you think that it is possible to recycle plastic bottles?	Yes No Maybe	81.92% 2.04% 16.03%
Do you think Oman needs to recycle plastic water bottles?	Yes No Maybe	86.30% 1.17% 12.54%
Do you think recycling plastic bottles can save energy?	Yes No	89.21% 10.79%

As evident from the results, the population is aware and knowledgeable about the possibility of recycling, the need of recycling in Oman and the ability of recycling in saving the energy. It was obvious from the question asked to people about the way they dispose plastic bottles that there are vast majority of people in Oman place the wastes in trach which indicates the need of recycling these wastes. In addition, it is reported in 2009 that the plastic waste percentage produced in Oman per year is about 12% [4]. Regarding the energy saving, it is proved that the energy required to make recycled polyester is approximately 75-84% less than that required to make virgin polyester [4], [5], which revealed that recycling plastic bottles can save the energy.

Figure 6 illustrate the results of the products that can produce from plastic bottle. It can be observed that the majority of respondents (66.5%) prefer to produce fabrics from recycled plastic bottles, while only 49.3% and 45.5% of respondents think that fuel and concrete, respectively were more preferable.

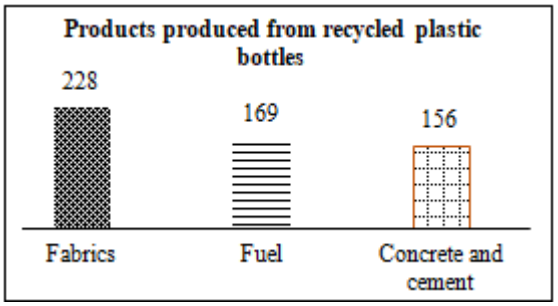

Figure 6: Products produced from recycled plastic bottles

As shown in the results, most of the participants prefer converting plastic bottles to fabrics, while almost the same percentage was selected for fuel and concrete and cement. This can be explained by the gender as most of the participants were females. The other thing the title of the survey indicates fabrics, and this might affect the selection. Different research studies show that plastic bottles can be converted to fuel and many countries started this production such as Germany Japan, and the United States [13], [14]. Moreover, Bangladesh has started to produce fabrics and concrete from plastic water bottles [1], [15].

3.5 Acceptance towards fabrics from plastic bottles

The question was distributed to know the acceptant of using the fabrics produced from plastic water bottle from the respondent. In this survey the result shows that 76.09% of the respondents would accept to buy the fabrics which are produced from recycled plastic water bottles while 23.9% of them did not accept it.

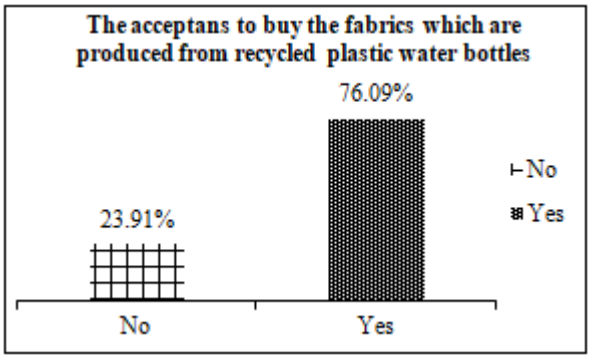

Figure 7: The acceptance of fabric produced from recycling plastic bottle

This question was followed by the reasons behind not accepting having the fabric produced from recycled plastic bottles. It was further investigated that 54 of females and 28 of males disagree with using fabrics. Their opinions were different after they were informed about the benefits of having the fabric from plastic such as self-cleaning and moisture control characteristics. It shows that the number of people went down to reach 58 participants.

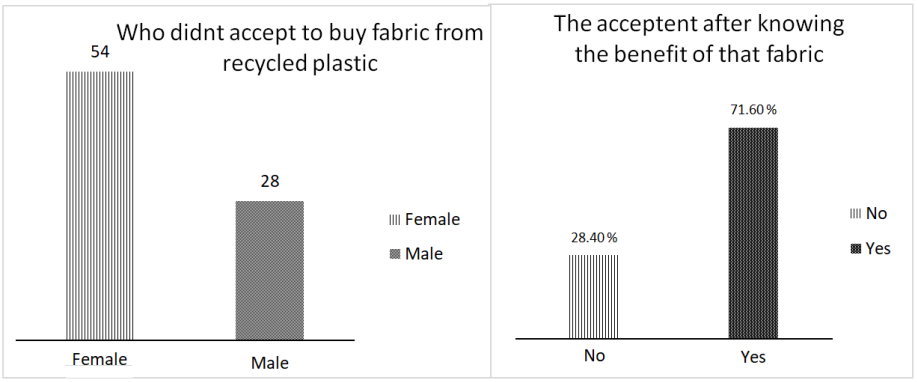

Figure 8: The reaction after knowing the benefit of the fabrics

According to a survey done by Centre for Design Research on Northumbria University in UK [16], which discussed the acceptance of having fabrics produced from plastic bottles, it shows that 75.6% of the respondents give a good reaction towards clothes made from recycled materials. On the other hand, it represents that only 24.4% are not feeling good by recycled materials for clothing. It seems that the majority of people seem not to be biased against recycled materials.

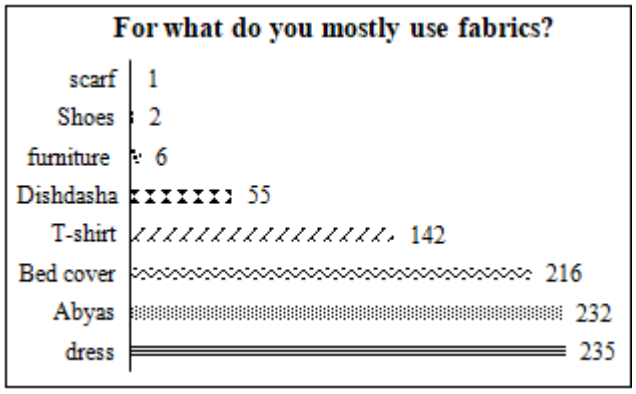

Figure 9: Usage of fabrics

Figure 9 shows the most usage of fabrics in Oman. The result presents that most of the respondents use the fabric for dress, abaya, bed cover, and T-shirts. The respondents provide a new idea for the fabric use other than what was on the choices which are furniture and 2 of them use the fabric for shoes and 1 for scarfs. This shows the need of fabric in our life.

There are three bases needed for humans which are food, shelter, and clothing. Because of the fast growth of the population, the need for clothes is an increase, which cannot be covered except by human-made fabric [17]. A research in Qatar [4] showed similar results to (**Figure 9**) in which participants chose of abaya and thobe. This is because of Qatar's population still maintains its tradition by wearing its national clothes on an ordered basis. What makes the Qatari condition more unique, that the national clothes are made of a polyester mix rather than a natural fiber cultivated locally. These two kinds of clothes provide national pride for the people who wear them. Similarly, people in Omanmostly female prefer to wear abaya when they go out either hanging out, occasions or even for the work. This can explain that most people use fabric in this kind of clothes.

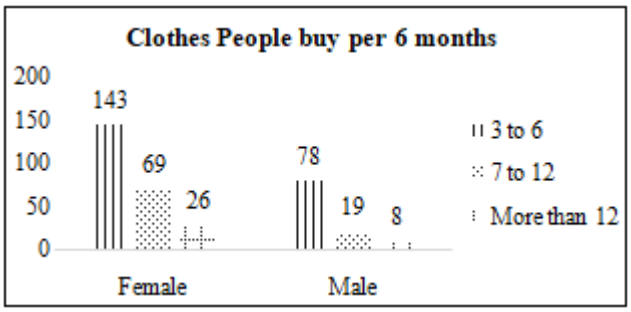

Figure 10: The clothes bought per 6 months

Respondents were asked about the number of pieces of clothes used per six months to estimate the required fabric production per year. The majority of respondents buy 3-6 clothes per 6 months were 143 from female and 78 from males, on the other hand, the lower number of respondents chose to buy more than 12 pieces and it was from 26 female and 8 of male. However, 69 of females and 19 of males prefer to buy 7-12 clothes.

This calculation considered the people who are using a plastic bottle. The calculated total number of dresses which will be bought by the respondents was found to be about 2019 dress per 6 months. For each dress around an average of 4 meters of fabrics is required. Finally, 8076 meters is bought every 6 months and for one year it will become 16152 meters. According to the survey it is showing that 173376 of different size of plastic bottle is consumed per a year and if it is converted to fabric, it will produce 8074.08 meters of fabric. It can be concluded that 50% of the population's need for fabric will be covered.

This calculation was done based on the study published in Qatar, an average of the Abaya-Thobe they buy per year was seven Abaya or Thobe, a similar calculation was applied in this survey which makes the full amount of needed that cover the need of fabric in Qatar is 17, 914, 104 meters/annum.

3.6 Preference way of collecting empty plastic bottle.

Figure 11 reveals the preference ways of collecting empty plastic bottles. More than half of respondents prefer bags collected from home, while 41.98% of respondents prefer to use containers at specific location to collect empty plastic bottles. As it has been noticed, opinions are similar between the two options, but the majority prefer to collect plastic bottles by bags collected from home. They chose this option may be because it is easier for them. Also, as mentioned in point (3.2), the weather in Oman is very hot, so it is difficult for them to go and throw empty plastic bottles into containers that may be far from the residence places. However, in other countries such as UK the recycling bins are in front of their homes.

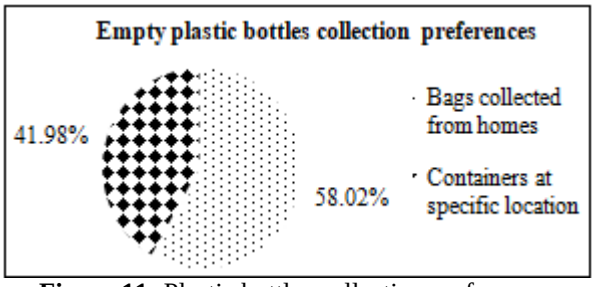

Figure 11: Plastic bottles collection preferences

4. Conclusion

The aim of this study is to investigate the possibility of recycling plastic bottles and convert them into useful fabrics that can be used for different applications. The survey of this study revealed that people in Oman consume plastic bottled water as a main drinking water source. This results in increasing number of empty plastic bottles in the environment which therefore can leads to serious environmental impacts. Recycling these wastes and producing secondary products can save the environment, energy, and water as well.A survey was distributed, and 343 responses were collected and out of the total surveyed, 73.7% preferred bottled water because its lightness, availability, cleanness and due to the hot weather in Oman, people need to have water with them everywhere. In addition, this study also found that most of the people dispose the empty plastic bottles in the garbage (75.22%) and only few of them reuse them. 86.30% of participants agreed that Oman needs to recycle plastic bottles, this shows that Oman needs to reconsider these wastes and benefit from them by recycling plastic bottle water especially that the population aware, knowledgeable and care about their environment. It was shown that 95.34% of the respondents believe that plastic bottled water can cause a serious environmental effect such as animal death, respiratory impairment, and environmental pollution, Furthermore, other respondents added some additional effects like poisoning, cancer, global warming, soil problems, and blockage of sewage systems. According to the results, it was found that around 16152 meters is bought per year. This study found that 173376 of different size of plastic bottle is consumed per a year. According to the calculation and the survey's result 8074.08 meters of fabric can be produced from recycling the used plastic bottle. This means that 50% of the population's need of fabric will be covered.

5. Future Scope

This project will be better to be continued by finding funds and communicating with different companies such as water and fabrics companies. The methodology that will be followed in future work will be mechanical recycling because it is environmentally friendly, simple, and requires low investment. It will include the plastic bottles collection, sorting, production, washing, drying, melting, converting the polyethylene terephthalate (PET) fragments to yarn and quality improvement.From this research, it is recommended to provide specific bags in each home for the collection of empty plastic bottles. These wastes can be then collected and recycled easily to fabrics as discussed in this study. After the production of fabrics, many usable items can be produced such as clothes, bags, shoes, curtains; bed and table cover which can be then sold in different outlets. It is also suggested to have various marketing campaigns to convince and reach largest segment of the society. For example, social media, social influencers, advertisements in different places.

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