Estimating the quantity of consumed plastic products and their economic returns in the city of Benghazi

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Highlights

- Plastic products have different consumptions based on their applications.
- The products produced from other plastic materials such as thermoset and epoxy are not studied.
- The product type and area for the study are the limitations of this work.
- PET products have the highest percentage of the consumed products.

ABSTRACT

Plastics recycling has gained significance and popularity over the last few decades due to environmental and economic reasons. Huge quantities of plastic products can be found in Benghazi city in places such as hospitals, restaurants, schools, factories, etc. Rather than accumulating these plastic products in the landfill areas, they can be recycled. Such an action preserves the environment and leads to great financial savings. This study aims to gather data on post-consumer plastic products from different locations and facilities in Benghazi. The plastic products have been classified into five types namely, PET, HDPE, LDPE, PP, and PS. The results revealed that many of the consumed products were PET. The study also reported the potential economic return of these products to some public institutions such as schools, the orphanage, and the homes of the disabled. Also, the study may serve as a starting point to the municipality of Benghazi and other local authorities towards improving the utilization of plastics waste and realizing the significance of their economic return.

Keywords: Recycling, consumed products, PET, HDPE, LDPE, PP, and PS.

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1. Introduction

The production of plastics has increased significantly in the last few decades motivated by the invention of several new techniques for producing polymers from petrochemical sources (Hopewell, Dvorak, & Kosior, 2009). This considerable expansion of the plastics industry is attributed to the fact that plastics are inexpensive, lightweight, and very durable (Andrady & Neal, 2009). Also, plastics can easily be shaped into various products and have a wide range of applications. However, plastics do not corrode, and they decompose very slowly (Shen & Worrell, 2014). These characteristics of plastics have caused many problems in the environment. One way to reduce these environmental problems is to recycle plastics. Recycling can be described as the process of reuse, recovery, or reclamation of waste material to extract value in the form of energy or new material (Elshenawi, 2017).

1.1 The need for recycling

One of the main factors is the quality of the recycled product. The quality of the recycled product depends on the molding machine,

- The quality of the tools used in the recycling process,
- The proper settings of the molding machine and its axillaries.
- The virgin material.

There is a variety of processed materials that are available for recycling. Many of these materials originated from post-consumer products, landfill material; material reclaimed from yards or mixed material. Non used products and defective products can also be used in the recycling process. Little is known about the effects of the processing of recycled materials. Regardless, recycling has been very attractive due to economic and environmental factors. In this regard, understanding the material properties significantly influence the quality of the recycled product.

1.2 Plastic Recycling Steps

The recycling process comprised of many sub-processes such as sorting, filtering, cleaning, drying,...etc (Fig. 1). These processes may lead to increased manufacturing costs (LA Mantia, 2002). The following are the steps of plastics recycling:
Step 1: Collection

This is the first step in the plastic recycling process, and it includes the collection of plastic waste from many locations such as houses, stores, hotels, restaurants, scrap yards, etc.

Step 2: Sorting

Sorting plastics is very important. Although the type of plastics has similar characteristics, adding a small percentage of incompatible plastics may spoil the batch. Such action may lead to deterioration of the product’s properties. There are various techniques in which the sorting process can be performed namely, manual sorting, X-ray detector, IR detector, laser detector, air sorting, melting/softening point, sink-float tanks, and selective dissolution.

Step 3: Washing and drying

After sorting, plastics must be washed and dried to remove any dirt or residues adhered to plastics from waste. The washing process has many advantages such as enhancing the purity of plastics and increasing the efficiency of the sorting process. After washing, plastics must then be dried with hot air to dry the plastic flakes.

Step 4: Granulating, and molding

To make the regrind materials resemble the raw materials in terms of size and shape, plastics need to be granulated. This granulating process improving the efficiency of the molding process and enhance the quality of the produced product.

2. Limitations

2.1 Product type:

The majority of the recycling works focused on post-consumer materials, landfill material; material reclaimed from yards or mixed material. In this study, post-consumer products were used; due to ease of recognizing them and hence, no need to sorting and filtration operations. Besides; the most used products were selected.

2.2 Key areas:

Due to military operations in some areas of Benghazi (during the period of this study) such as city center and Alsabry; free and safe areas were selected.

3. Procedure

3.1 Study Duration:

The year 2016/2017 was selected to execute the study. This in part is due to the availability of data at that period. Such data is considered, after close examination, sufficient and clear data that meet study requirements.

3.2 Selected Areas for this study:

This study was carried out in most areas within the city of Benghazi (referred to in green as shown in Fig. 2), except for areas within the limits of military operations such as Sabri, City center, Qanfouda, Qawarshah and Qaryounis (red areas as shown in Fig. 2).

Table 1

<table>
<thead>
<tr>
<th>Product name</th>
<th>Type of material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water bottle (0.5 L)</td>
<td>PET</td>
</tr>
<tr>
<td>Nesquik bottle</td>
<td>HDPE</td>
</tr>
<tr>
<td>Water cup</td>
<td>PP</td>
</tr>
<tr>
<td>Spoons</td>
<td>LDPE</td>
</tr>
<tr>
<td>Nail polish remover bottle</td>
<td>PS</td>
</tr>
<tr>
<td>Drinking water pack (16 L)</td>
<td>Water bottle</td>
</tr>
<tr>
<td>Liquid soap bottle</td>
<td>Drinking cup</td>
</tr>
<tr>
<td>Hand bottle</td>
<td>Forks</td>
</tr>
<tr>
<td>Yogurt cup</td>
<td>Mustard pack</td>
</tr>
<tr>
<td>Case of bottled water (0.5 L)</td>
<td>Pack of butter</td>
</tr>
<tr>
<td>A laundry soap pack- age</td>
<td>Chocolate box</td>
</tr>
<tr>
<td>Case of bottled water (1.5 L)</td>
<td>A tray of milk</td>
</tr>
<tr>
<td>Pack of soft drink</td>
<td>Fabric frag-</td>
</tr>
<tr>
<td>Pack of soap</td>
<td>Antiseptic floor-</td>
</tr>
<tr>
<td>Pack of cooking oil</td>
<td>Cleaning bottle</td>
</tr>
<tr>
<td>Natural juice box</td>
<td>Chocolate box</td>
</tr>
<tr>
<td>Pack of ketchup</td>
<td>Ceramic cleaner</td>
</tr>
<tr>
<td>Mayonnaise pack</td>
<td>Bleach bottle</td>
</tr>
<tr>
<td>A bottle of vinegar</td>
<td>Hair shampoo</td>
</tr>
<tr>
<td>A bottle of milk</td>
<td>Hair cream bottle</td>
</tr>
<tr>
<td>A bottle of butter</td>
<td>Hair oil bottle</td>
</tr>
<tr>
<td>Pack of peanut butter</td>
<td>Hair oil bottle</td>
</tr>
<tr>
<td>Baby powder pack</td>
<td>Hands cream bottle</td>
</tr>
<tr>
<td>A bottle of vanilla liquid</td>
<td>Children cream bottle</td>
</tr>
<tr>
<td>Toothpaste tube</td>
<td>Children cream bottle</td>
</tr>
<tr>
<td>Diapers food box</td>
<td>Shaving cream tube</td>
</tr>
<tr>
<td>Polished glass pack</td>
<td></td>
</tr>
<tr>
<td>Pack of hair gel</td>
<td></td>
</tr>
<tr>
<td>Pack of baby shampoo</td>
<td></td>
</tr>
<tr>
<td>Carpet Freshener bottle</td>
<td></td>
</tr>
</tbody>
</table>
3.4 Data Sources

The teamwork of this study prepared a specific form to collect different information about the used products as shown in Fig. 4. This form is translated into the Arabic language to fill it easily.

### Fig. 4. Data collection form

Many visits have been carried out to many places in Benghazi such as houses, schools, companies, hospitals, factories, restaurants, cafes, etc. Three selected schools were selected in each targeted area in Benghazi as shown in Table 2. The name of other selected places for the data source such as hospitals, restaurants, banks, banquet halls, and companies are shown in Table 3.

### Table 2

<table>
<thead>
<tr>
<th>Region</th>
<th>School name</th>
<th>No. of houses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hay Al-</td>
<td>Shohadaa Al watan</td>
<td>24</td>
</tr>
<tr>
<td>参数中省略</td>
<td>AL.Sada Hajar</td>
<td></td>
</tr>
<tr>
<td>Shabab AL</td>
<td>thawra</td>
<td></td>
</tr>
<tr>
<td>Afluwayhat</td>
<td>AL. Theqa</td>
<td>25</td>
</tr>
<tr>
<td>Shohadaa Al Zentan</td>
<td>Yousef Boker</td>
<td>23</td>
</tr>
<tr>
<td>Khaliied Ben Al</td>
<td>Zohor Al pianas</td>
<td></td>
</tr>
<tr>
<td>AL.Noor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tabaleno</td>
<td>Madal Al marrif</td>
<td>25</td>
</tr>
<tr>
<td>jeser AL</td>
<td>Marraif 1</td>
<td>24</td>
</tr>
<tr>
<td>Ebh Khaldon</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bohdema</td>
<td>Tapouk</td>
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</tr>
<tr>
<td>AL.Aqs</td>
<td>Mousaab Ben</td>
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<tr>
<td>Alhawari</td>
<td>AL.Mostaqbal</td>
<td>23</td>
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<tr>
<td>AL Dawlia</td>
<td>Noor AL. Maarif</td>
<td></td>
</tr>
<tr>
<td>Baloun</td>
<td>AL.Owla</td>
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</tr>
<tr>
<td>Om Habeba</td>
<td>AL.Taysseer AL</td>
<td></td>
</tr>
<tr>
<td>Alberca</td>
<td>Sadeq Balla</td>
<td>22</td>
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<tr>
<td>Tarik Ben Zeyad</td>
<td>Mashaal AL.Wahda</td>
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</tr>
<tr>
<td>Allathhi</td>
<td>AL.Sedeqa</td>
<td>24</td>
</tr>
<tr>
<td>AL.Ald</td>
<td>AL.Mawred 1</td>
<td></td>
</tr>
<tr>
<td>Gardens</td>
<td>Hadeq</td>
<td>25</td>
</tr>
<tr>
<td>Marczaz AL</td>
<td>Dyar Al Alem</td>
<td></td>
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<tr>
<td>Mot</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shibna</td>
<td>Noor Almarifa</td>
<td>23</td>
</tr>
<tr>
<td>Zohoor Bengazi</td>
<td>AL.Fadeel Bo Omar</td>
<td></td>
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<tr>
<td>Eastern</td>
<td>Salmani</td>
<td>24</td>
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<tr>
<td>Sadiq</td>
<td>Fatat Al-thawra</td>
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</tr>
<tr>
<td>AL. Oroba</td>
<td></td>
<td></td>
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<tr>
<td>Western</td>
<td>Alsalmani</td>
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<tr>
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<td>Oby Ben Kaab</td>
<td></td>
</tr>
<tr>
<td>AL.Najem AL.Sataa</td>
<td></td>
<td></td>
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<tr>
<td>Sedi Hussennn</td>
<td>AL.Motaf-waqqen</td>
<td>25</td>
</tr>
<tr>
<td>2 Mares</td>
<td>Shohdaa Yanayer</td>
<td></td>
</tr>
<tr>
<td>Alwa Hashi</td>
<td>AL.Gahera</td>
<td>22</td>
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<tr>
<td>Om AL. Qora</td>
<td>Shodaa AL. Hani</td>
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</tr>
<tr>
<td>Aharer Street</td>
<td>perintchy</td>
<td>23</td>
</tr>
<tr>
<td>24 December</td>
<td>Rainbow</td>
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</tr>
<tr>
<td>Elkeesh</td>
<td>AL.Amal AL.Kabeer</td>
<td>25</td>
</tr>
<tr>
<td>Jabal Nafsa</td>
<td>AL.Qayarawan</td>
<td></td>
</tr>
<tr>
<td>Boutiti</td>
<td>Aser AL. horia</td>
<td>23</td>
</tr>
<tr>
<td>AL.Amal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 Street</td>
<td>AL.Somod</td>
<td>21</td>
</tr>
<tr>
<td>AL.Watheqa</td>
<td>AL.Mawred 2</td>
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</tr>
<tr>
<td>Alkaiwefa</td>
<td>Basheer AL. Naser</td>
<td>24</td>
</tr>
<tr>
<td>AL.Ald Alfeddi 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jossor AL. Maarifa</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 3.5 Calculation of economic return:

Initially, the mass should be determined in order to calculate the economic return. In this study, the product mass was obtained by weighing it using a digital weighing scale. The economic return can be calculated in this way:

\[
\text{Sell price (LD/Kg) } \times \text{ Material amount (Kg)}
\]

It has been found that the sale price per kilogram for any type of product is 0.7 LD/Kg (Database of LUJAIN plastic factory).
Table 3
The names of the places of data sources

<table>
<thead>
<tr>
<th>Hospitals</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>EL Safwa Hospital</td>
<td>EL Galaa Hospital</td>
<td>Libyan-German Hospital</td>
</tr>
<tr>
<td>Mother Hospital</td>
<td>Center of Communicable Diseases</td>
<td>Internation University</td>
</tr>
<tr>
<td>Benghaz Medical Center</td>
<td>Pectoral Hospital</td>
<td>Kidney Center</td>
</tr>
<tr>
<td>College Of Dentistry</td>
<td>Alhawary General Hospital</td>
<td>Children Hospital</td>
</tr>
<tr>
<td>Restaurants and cafes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pizza Soliman</td>
<td>AL Deyafa</td>
<td>Be Al Beak</td>
</tr>
<tr>
<td>AL Omda</td>
<td>AL Robyen</td>
<td>Vabiano</td>
</tr>
<tr>
<td>Paris</td>
<td>Kudo</td>
<td>Toscana</td>
</tr>
<tr>
<td>Jura</td>
<td>Pordo</td>
<td>AL Moad</td>
</tr>
<tr>
<td>AL Nahla</td>
<td>AL Henry</td>
<td>Linza</td>
</tr>
<tr>
<td>Bo Hjer</td>
<td>AL Khayrat</td>
<td>Randa</td>
</tr>
<tr>
<td>Banks</td>
<td>AL Aman</td>
<td>Banke</td>
</tr>
<tr>
<td>AL Jamela</td>
<td>AL Bahja</td>
<td>Venecia</td>
</tr>
<tr>
<td>AL Hadeel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Companies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Libyana</td>
<td>Arabian Gulf Oil company</td>
<td>Noor AL Bayad</td>
</tr>
<tr>
<td>Abar Libya</td>
<td>General works company</td>
<td>HP Group</td>
</tr>
<tr>
<td>Benghaz</td>
<td>AL Amal</td>
<td>AL Tawflq</td>
</tr>
<tr>
<td>AL Madar</td>
<td>Social Solidarity Fund</td>
<td>ALNasma</td>
</tr>
<tr>
<td>Nabaa AL Hayat</td>
<td>Dreams</td>
<td>White Birds</td>
</tr>
<tr>
<td>Municipal-ity of Ben</td>
<td>AL Nahda</td>
<td>AL Ryada Group</td>
</tr>
<tr>
<td>National Oil Com.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig. 5. The weight (%) of PET products

It can be noted from Fig. 4 that the pack (bottles wrapped together in nylon box) of drinking water (18L) has the highest weight percentage (67.38%). This is probably due to the large consumption of the pack of drinking water (18L), which can be observed in our daily life. On the other hand, the teamwork of this study classified the data according to the sources of data inside Benghazi; where it was found that the companies (service or production companies) have the highest consumption rate for the PET products which expressed as a percentage of the weight (42.4%) as shown in Fig. 6.

Fig. 6. The weight (%) vs PET data sources

According to the results obtained, it is clear that there are significant variations between plastic products consumed. This variation in products consumption may be caused by the large use of some of these products. In this regard, it is useful to clarify these discrepancies, which have been classified according to the type of material as shown in Fig. 7.

Fig. 7. Percentage of weight for all material

Fig. 7 shows the consumed products of PET, which have the highest percentage (83.76%) compared to other materials. This may be because the nature of products such as the pack of drinking water, and the pack of bleach glass are widely used in companies. The companies are one of the most popular places crowded with people, and hence the largest consumer of these products. On the other hand, the results of the study indicated that there are significant differences in the products consumed between different data sources. Fig. 8 shows a variation in the percentage of products consumed between data sources and the companies have the highest percentage (87%). The possible reason for this result is: the companies are one of the busiest places, especially during the study period due to the problem of cash shortage of the Libyan currency.

Fig. 8. Percentage of weights for all data sources
4.2 Estimating potential economic returns

Based on the data of the total weight of all products and their sale prices; the economic return can be calculated simply by multiplying the total weight to the selling price as mentioned before. For example, the economic return of all consumer PET products can be calculated as: 30029.281(kg) * 0.7 (LD/kg)=21020.4967 (LD).

Fig. 9. Percentage of weights for all data sources for all materials

It can be observed from Fig. 9, that the companies have the highest percentages of weight for most types of materials. That is due to many service companies in Benghazi, as well as production and cleaning companies that used a large number of employees whom they use these products. Hospitals also have the highest weight (48%) of PP products because of the nature of this material and its product uses.

5. Conclusion

This study provides useful information about the products consumed in the city of Benghazi. The following points can be concluded:

- Based on the collected data, the most consumed products in Benghazi according to the type of material are PET, HDPE, PP, LDPE, and PS.
- PET products have the highest economic return (LD 21020).
- HDPE products have an economic return (LD 2689.54).
- PP products have an economic return (LD 969.06).
- LDPE products have an economic return (LD 22.41).
- PS products have an economic return (LD 394.47).
- The companies as a source of data have the highest percentage of the weights of consumed products (41%) and thus they have the highest economic return (LD 10245).

Acknowledgment

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References


Database of LUJAIN plastic factory (2017)


