

Environmental Assessment of Polyethylene Bags: A Case Study in Khartoum State, Republic of Sudan

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Abstract: Polyethylene or polythene bags are made from ethylene, a gas that is produced as a by-product of oil, gas and coal production. Most plastic is not biodegradable and will survive in the environment for hundreds of years. Sudan has seen an increasing problem with plastic waste as Khartoum state alone generated 132,112 tons annually. Therefore, the effects of the polyethylene bags refuse on the environment were studied in Sudan (Khartoum), as an attempt to highlight the current consumptions surrounding the impact on the amount of litter generated and opportunities for their management. **Methods:** Data of the study were collected by different quantitative and qualitative methods. **Results:** It is evident that, the larger proportion (92.8%) of the respondents used plastic bags more frequently as almost all aspects of daily life involve plastics use, so it leads to generation of huge quantity of plastic waste. Polyethylene bags factors (i.e., Cheap, light weight, nice and easy to use) responsible for increasing trends of their usage and waste. All plastic waste materials are mixed with municipal solid wastes that are either land filled or incinerated. Nevertheless, only 35% of this solid waste quantity is transferred to landfills, while the remaining 65% is disposed of in open dumps. Therefore, light materials such as polyethylene bags in open containers and/or open dumps can easily float in a natural environment. However, the concern about their usage and disposal are not sustainable due to the misuse and ill managements. Beside the subsequent physical problems for wild and domestic mammals that die each year because of eating or being entangled in plastic. The situation is worsened in economically disadvantaged countries like Sudan. **Conclusion:** On the light of the study results, the flow of plastic on the environment need to be stopped and the research encourages the usage of paper and traditional bags. Beside recycling and public awareness, especially the decision maker will be so helpful to take serious actions.

Keywords: Polyethylene bags, waste management, Environmental Assessment, Khartoum-Sudan

1. Introduction

Plastics are non-biodegradable, synthetic polymers derived primarily from Petro-fossil feedstock and made-up of long chain hydrocarbons with additives [1]. It's made from ethylene, a gas that is produced as a by-product of oil, gas and coal production [2]. Ethylene is changed into polymers (chains of ethylene molecules) and/or pellets called polyethylene or polyethylene, which are used by plastic manufacturers to produce a range of items, including plastic bags [3].

There are two categories of plastic shopping bags, the high density polyethylene 'singlet' bags (HDPE) and the low density polyethylene bags (LDPE). HDPE has the density range from 0.941 to 0.965 g/cm³. LDPE (0.916 to 0.925 g/cm³) is thick and soft and can be transparent and glossy in appearance [2]. LDPE is used in shopping bags usually with attached handles and cannot be recycled, i.e., Unlike HDPE. Plastic bags are very popular with consumers for carrying their purchases, with little lasting effect. There are intensive uses of polyethylene bags because they are cheap, strong, lightweight, and functional for carrying food and other goods [4].

The plastic products are the most rapid developing, highly competitive international industries and they are closely related to human life. It is estimated that somewhere between 500 billion and one trillion plastic bags are consumed throughout the world each year [5]. From 2009 to

2010 the global production increased by 15 million tonnes (6%) to 265 million tonnes, confirming the long term trend of plastics production growth of almost 5% per year over the past 20 years [5]. In 2010 Europe accounted for 57 million tonnes (21.5%) of the global production and China overtook Europe as the biggest production region at 23.5% [6]. In Sudan, Khartoum State produced around 1,040,250 tons of solid municipal waste annually and 12.7% of it is plastic [7]. However, concerns about plastic bags usage and disposal are diverse and include accumulation of waste in landfills and in natural habitats, causing pollution, killing wildlife, and using up the precious resources of the earth [8] [9] [10] [11] [12] [13]. However, the quantitative studies on plastics waste in general and polyethylene bags refuse in particular are almost lacking in Sudan. Therefore, effects of plastics waste on the environment require genuine research to shed the light on the magnitude of this problem.

The main objective of this study was to assess the usage and quantities of polyethylene bags, their disposal and adverse impacts on the environment.

2. Material and Methods

2.1. Description of the Study Area

The study was conducted in Greater Khartoum, the tri-capital city of Sudan in North East Africa (Figure 1). It is situated on latitude 15 36 N, and longitude 31 32 E, and it is

1352 ft above sea level [14]. Its population has grown to over 5 million people [15].

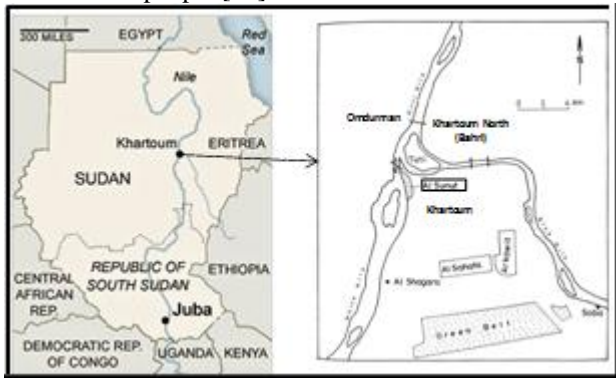


Figure 1: A map showing the relative position of the study area and study sites within Khartoum City (Arkawit, AlSunut and AlSahafa)

Over 1 million people live in Khartoum city which is situated at the confluence of the Blue Nile and the White Nile. The main economic activities are agriculture, commerce (provision of basic services), and small manufacturing enterprise. The study subjects were selected using random sampling techniques (Marshall, 1996) from three localities (Arkawit, AlSunut and AlSahafa areas, Fig. 1) In Khartoum city.

2.2 Data Collection Procedure

Data of the study were collected by different quantitative and qualitative methods (Table 1).

Table 1: Data of study survey questions

Data Variations / Types		
	Solicited	Spontaneous
Quantitative Data	Quest. Interviews	Observation (Passive)
		Admin. Records
Qualitative Data	Literature Review	Databases
	Open Group Interviews	Internet Survey
		Govern. Archives
	Focus Group Interviews	Observation (Participant)

Quest. = Questionnaire; Govern. = Governmental; Admin. = Administrate

2.2.1. Observation

The direct observations of the visited places include: final disposal sites, animal and agricultural farms, restaurants, institutions, markets, veterinary hospitals, open spaces/fields, street sides, hotels, groceries, trades and residential houses. During all these visits, notes of the amount, rate of accumulation and distribution of polyethylene bags refuse were recorded and a few photographs were taken.

2.2.2. Literature Review

2.2.3. Interviews

It includes questionnaires and semi-structured individual interviews.

2.2.3.1. Open and focus group interviews

Government Health Officials at Ministry of Health, especially the director of environmental health

administration and local councils of Khartoum State were interviewed regarding waste management services and practices. However, data were gathered to shed light on the responsibilities of the ministry and local councils. Health inspectors and scavengers were consulted via informal (face-to-face) interview to give a comprehensive idea about the plastic waste management, methods of solid waste treatment, and policies of plastic waste and/or refuse collection. Therefore, the questions asked were about solid waste management in general and polyethylene bags in particular towards obtaining information on:

- The amount, characteristics and origin of solid waste being generated,
- Municipal solid waste collection and disposal status and problems,
- Ways to mitigate polyethylene bags refuse with the general domestic solid waste,
- Ways of sorting polyethylene bags refuse from domestic solid waste and/or recycling,
- Environmental impact of uncollected plastic bags and randomly dumped waste, and
- Their satisfactions about the municipal solid waste management.

2.2.3.2. Household Questionnaire

A representative sample of 360 household respondents that consisted of 200 males and 160 females within the three selected residential areas of a Khartoum city (Arkawit, AlSunut and AlSahafa sites, Figure 1) were surveyed for data collection.

The selection was made from neighboring households which were in the distance of 100 to 200 m far from each other. Among the visited households, at least one member of the family was picked randomly for the study, regardless of his/her age, educational status, sex and occupation as long as he/she was willing. The number of male respondents was higher than female respondents due to the fact that males showed more readiness to be interviewed and fill the questionnaires provided. Prior to the administration of the questionnaires, conversations were held with the selected respondents to explain the objective of the study. As well as, respondents who were willing but not able to attend the questionnaires by themselves were helped by data collectors. The questionnaires were designed to collect information such as

- Socio-demographic data that include sex, age, education, size and average monthly income of the family,
- Residence and accommodation type,
- The preference factors, and average number of polyethylene bags used/day,
- Domestic's solid waste components, container types beside the frequency and means of waste collection, and
- Household awareness about polyethylene bags use and reuse beside general waste hazard.

2.3. Statistical Analysis

The observations in each group were compiled and tabulated for the assessment of frequencies and percent. Analysis of the collected data was carried out using SPSS software

version 16. Statistical multivariate analysis was done using the ratio of the F-statistic and significance was accepted at $P < 0.05$.

3. Result

3.1. Socio-demographic information and polyethylene bags used/day in Khartoum city

Based on the collected data, the respondents were grouped into different categories (Table 2). Three studied sites (Figure 1) were merged as they have the similar socio-demographic data, following others [15] [16].

Table 2: Respondents Socio-demographic Information

<i>Socio-Demographic Data</i>	<i>Frequency</i>	<i>Percentage %</i>
Sex of Respondents		
Male	252	70%
Female	108	30%
Total	360	100%
Age of Respondents		
25-35	48	13.4%
35-45	201	55.8%
45 & above	111	30.8%
Total	360	100%
Education Level of Household		
Illiterates	72	20%
Basic	190	52.8%
Graduate	98	27.2%
Total	360	100%
Family Income level		
Low	32	9%
Medium	188	52.2%
High	140	38.8%
Total	360	100%
Family Size		
Small	30	8.3%
Medium	138	38.8%
Large	192	53.32%
Total	360	100%

The trend of polyethylene bags used/day per household in Khartoum city (Table 3) showed that the majority (92.8%) of the respondents use ≥ 4 polyethylene bags in their daily domestic needs. Those who use only one bag per day constitute about 10.8% of sampled causes, while only 1.4% doesn't use polyethylene bags.

Table 3: Average number of polyethylene bags used/day per household in Khartoum State

<i>Polyethylene Bags/day</i>	<i>Not Used</i>	<i>Few use (1-3)</i>	<i>Medium use (4-6)</i>	<i>Excessive use > 6</i>	<i>Total</i>
Per Capita Plastic Bag Consumption	5	39	132	184	360
Percent of Plastic Bag used/day	1.4%	10.8%	36.7%	51.1%	100%

This has been confirmed by the country statistical import records from 1993-2012 [19]. Nevertheless, most studies confirmed the abundance of plastics and/or polyethylene items as a category in Khartoum solid waste, the second item in the general domestic solid waste [11] [16] [17].

Most respondents with the larger family size that associated with high and medium income show the greatest number of polyethylene bags used/day. The multivariate analysis revealed that income and family size affects polyethylene bags used/day (more than four, ≥ 4) (at $F < 0.05$) but does not affect the bags number/day below four since none of them had significance below 0.05 [20].

3.2 Polyethylene Bags Preference Factors

Almost most of the interviewed households (98.5%) use polyethylene bags (Table 3). There are many factors which affect the preference of polyethylene bags use as revealed in table (4).

Table 4: Polyethylene bags and factors responsible for increasing trend of their usage

<i>Factors</i>	<i>Cheap Only</i>	<i>Light weight only</i>	<i>Nice only</i>	<i>Available only</i>	<i>All factors</i>	<i>Un-Specify factor</i>	<i>Total</i>
Percentage	9.5	4.6	3.0	5.0	76.3	1.4	100%

Therefore, combined preference factors of polyethylene bags (i.e., cheap, light-weight, nice, and available, Table 4) responsible for increasing trends of their usage in daily life and in a wide range of food, drink and other goods. These findings are consistent with other reports describing that light-weight, cheap price, excellent fitness for use and resource efficiency as main reasons for widespread utilization of plastic bags by billions of customers throughout the world [4] [18]. Though lack of alternative materials was mentioned as additional contributing factors for excessive utilization of plastic bags in Khartoum state [12].

3.3. Polyethylene Bags Problems

The problems associated with plastic bags were reported in Table 5. According to the questioned households (15.3%, Table 4), food kept for a long time in polyethylene bags lead to food spoils (i.e., rotting).

Table 5: Polyethylene Bags Problems

<i>Problem</i>	<i>Number</i>	<i>Percentage</i>
Food rotting	55	15.3%
Transmission of		1.9%
Formation of soot	15	4.1%
Animal death	24	6.7%
None-aesthetical	24	6.7%
More than one	235	65.3%
Total	360	100%

Polyethylene bags restore water, air and heat for longer periods [21] thus creating favorable conditions for micro-organisms growth and food fermentation [22]. Also, 1.9% of the respondent noticed that when polyethylene bags were opened by air blowing from mouth, it might contribute to the spread of contagious diseases, especially respiratory tract infections [21] [22]. As well as Animal death and none-aesthetical impact were recorded for 6.7% (Table 5). However, the collection of the waste is a kind of a joint venture which includes the Khartoum city council authorities and a private company that applying door-to-door system [23]. Moreover, the duration of domestic solid waste

collection in Khartoum Province is irregular, ranges between once to three times a week (Table 6).

Table 6: Frequency of collection/week in Khartoum

Frequency of collection/week	Once	2 Times	3 Times	Irregular	Total
Collection Number	125	37	10	188	360
Percentage	34.7%	10.3%	2.8%	50.2%	100%

50.2% of the households agree upon the irregular weekly duration of domestic solid waste collection. Nevertheless, in many cities of the developing countries, there is an insufficient collection of the solid wastes being generated [24] [25].

According to Ahmed, In Khartoum state 55.1% of the households store the domestic solid waste in uncovering containers, and only 10.8% in covered ones [12]. Therefore, light materials such as polyethylene bags in open containers can easily float in air and water, and travel long distances causing non aesthetical impact when nested, stuck in chain, fences and shrubs (Figure 3 and Table 5).



Figure 3: Open areas with a high accumulation of plastic bag wastes in Khartoum City, Sudan

3.4 Effects of Polyethylene Bags, Refuse on Domestic Animals

In Khartoum State (Table 7), the number of foreign bodies removed surgically from domestic animals is on the increase year after year [26].

Table 7: Foreign Bodies Removed During Clinical Operation in Khartoum State

Clinical Operation	2004-2005	2006-2007	2008-2009
Foreign body	911	966	1498
Dystocia	621	325	327
Milk fistula	127	129	273
Amputation	182	155	-
Hernia	63	60	35
Tumer & Abscess	271	99	-
Others	360	365	68

Beside that Clinical Operation of Foreign Bodies recorded at the top among the other Veterinary Surgical Operations in Khartoum state (Table 7).

However, improper management of municipalities and household domestic solid waste, causing non aesthetical impact beside subject animals to foreign bodies diseases that caused by ingestion of polyethylene bags refuse (see

previous section 3.3). Therefore, the above results indicated that there is an urgent need to raise the public awareness about polyethylene bags impact. This will help in the preservation and restoration of the general environment, animals' habitats and feed [26] [27] [28].

3.5. Assessment of Environmental Condition Of The Khartoum

All plastic waste materials are mixed with municipal solid wastes that are either land filled or incinerated [12] [25]. As only 35% of this solid waste quantity is transferred to landfills, while the remaining 65% is disposed of in open dumps [25], where both of them prove to be a disaster for the environment [26] [27]. Incineration leads to air pollution, whereas dumping the waste in open areas causes contamination of environment, water bodies and soil. Thus, an alternative treatment of plastic waste is required as early as possible, such as waste recycling that will satisfy all aspects of durability and appropriate use of resources. In most of the situations, plastic waste recycling could also be economically viable, as it generates resources, which is very important for most of the national and local governments.

4. Conclusion

Economic growth and changing consumption and production patterns are resulting in rapid increase in generation of plastics waste in the world. Due to population increases, the demand for plastic products has steadily increased over the last 40 years and waste plastics are becoming a major stream in solid waste, especially in developing countries [6] [26] [27] [28]. Total imports of the Republic of Sudan in Plastic and articles thereof sector were about US \$280.87 million in 2009 and the share of a sector of the total Republic of Sudan's imports, in value, was 3.27 %, with 34.65% of polyethylene raw materials (Polymers of ethylene) out of total sector imports [6] [15]. In Khartoum State (with a population of approximately 5 million), the solid waste generated ranges between 0.6 and 1 kg per capita/day (totaling 3,200 tons). The environmental impacts resulting from the accumulation of plastic waste are huge and increasing [14]. Since plastics are non-biodegradable [26], they cannot be easily returned to the natural carbon cycle; hence the life cycle of plastic materials ends as waste. Nevertheless, disposal facilities polyethylene bags refuse affects wildlife, human health, and the environment [4] [12] [20].

The current study established the following:

- Absence of solid waste management, effective strategies in Sudan,
- Limited financial resources coupled with outdated machines and equipment, poor maintenance operations, and low wages,
- Polyethylene waste is the major constitute of domestic solid waste.
- The level of income of each household group determines the number of polyethylene bags used/reused per day, and the more plastic waste is generated.
- Lack of public awareness regarding polyethylene bags use/reuse problems.

5. Recommendations

Effective and efficient management of waste, including application of 3R (Reduce, Reuse, Recycle) is an essential element for promoting sustainable patterns of polyethylene bags consumption and production. There is a need to develop an integrated waste management plan for Khartoum city with a priority on plastic waste recycling to reduce the final amount of waste for disposal. Beside an environmental awareness program among citizens, workers and decision-makers on polyethylene bags refuse impacts.

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