INTERNATIONAL JOURNAL OF NATURAL AND APPLIED SCIENCES (IJNAS), VOL. 5, NOS.1& 2 (2010); P. 21 – 27, 2 TABLES, 11 FIGS.

Material recovery from recycling polyethylene an environmental pollutant in Nigeria

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ABSTRACT

This study investigates the environmental pollution caused by polyethylene (cellophane) material in Nigeria. Polyethylene was generated at two location: one at the market place and the other at home. Fifty respondents in the market were given two waste baskets each to determine the rate and type of cellophane generation and disposal. It was found that the dry season months of (November to March) are higher in the generation and disposal of this material than the wet season months of (April to October). Based on the type of cellophane, table water sachet topped the list followed by cellophane for assorted items, ice cream and biscuit wrappers in that order. Polyethylene generation was higher in the market than at home. Cheapness and availability are some of the reasons for constant patronage of cellophane. Indiscriminate polyethylene disposal has constituted environmental nuisance and degradation. For cleaner and sustainable environments, vigorous enlightenment campaign, proper collection techniques and recycling among others are recommended.

INTRODUCTION

Polythene materials are used widely in many consumer products, including as wrapping products, for storage of beverages and manufacturing of toys , car components, bullet proof suits, etc. They have substituted ferrous, wood and ceramic materials in many applications for which reason, polythene consumption has increased exponentially in the past decades. Until recently, polythene wastes were disposed into landfills. This disposal method creates environmental pollution and space problem because the waste materials are not easily biodegradable unlike other materials of similar usage.

To resolve environmental pollution caused by polythene waste in Nigeria, we have to adopt a new management approach for polythene waste products (i.e. recycling, instead of disposing into landfill or environment). The land gets littered by polythene bags garbage presenting an ugly and unhygienic scene. The garbage finds its way into the city and drainage system causing blockage and difficulty in maintenance of the drainage, with increased cost.

Recycling involves processing of post -consumer materials to produce raw materials for new products. It has been widely used and can help to increase plastic recovery because increasing knowledge about property conversion will increase the demand for recycling of the polythene material.

The environmental management and control of polythene waste through recycling will transform the waste to reusable product thereby reducing the pollution caused by this waste in the Nigerian environment. Reuse of waste from polythene products could require the conversion of used sachet water bags for the production of candle (Edoga et al. 2007) and possible reuse of the catalytically degraded product into fuel oil (Jalil, 2002). Application of sphingomonas bacteria can degrade over 40% of the weight of plastic bags in less than three months (Wikipedia, 2009).

The objectives of this study were: to monitor the level of pollution caused by polythene waste in the Nigerian environment, particularly in residential, commercial, and institutional centres; to identify the potential sources of these environmental problem in Nigeria, and to draw appropriate conclusions and make recommendations regarding the solution of the problem. This work will help to assess the levels of pollution caused by polythene waste which can also be a source of carbon monoxide (CO) a poisonous gas in the atmosphere, resulting from polythene burning.

Nature of polythene and resultant waste/pollution derives

Polythene materials derived from a chemical compound known as polyethylene $(C\text{-}H)_n$ which is manufactured from the polymerization of ethylene (C-H) and is represented in Fig.1. Basically, polyethylene is an odorless, translucent solid, commercially available in pellet form which is convertible to derivative products such as the polythene bags. Pep is a stable and inert polymer, exhibiting very high resistance to chemical attack.

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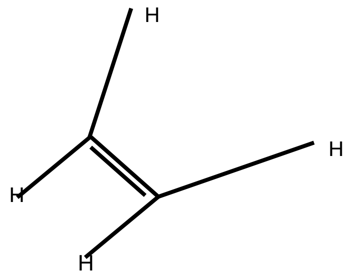

Fig. 1. Polyethylene structure

Polythene materials are classified into several categories based mostly on its density and branching. The mechanical properties of polythene depend significantly on variables such as the extent and type of branching, the crystal structure and the molecular weight, with regard to solid volumes. The most important polythene grades are high density polythene (HDPE), medium density polythene (MDPE) and low density polythene (LDPE) (Wikipedia, 2009).

The surface of the earth where man spends his entire life has undergone drastic changes arising from man's intervention in many natural processes. The changes includes the effect of waste products such as acids chemicals, oils and grease, suspended and desolved solids, heavy metals ions, mercaptans, packaging materials etc. Of all classes of wastes, polythene waste poses the greatest threat to life, because it has the potential of polluting land, water and air using water and air as transport media (Ibanga, 2000).

Water is very essential to plant and animal lives. It is being polluted as a result of the introduction of polythene waste in form of gases, liquid (sludge) and solid into a body of water which affects both the surface and underground water. Polythene waste destabilizes the characteristics of water and affects its temperature, taste, odour, colour, turbidity, amount of suspended solids(ss), and electrical conductivity of water. It has also been observed that fish and other marine species in the water ways misunderstanding polythene material as food items, swallow them and die (West, 2006).

Lands are being polluted as a result of indiscriminate dumping of polythene waste. Many materials manufactured from polythene, example slippers, plastic shoes, chairs, toys are discarded when they are spoiled and this constitutes polythene waste. These polythene wastes apart from reducing the aesthetic value of land can also degrade to produce simple chemicals which may be poisonous and harmful to health, thus the damage done to the environment by polythene waste can be reduced through minimization of waste production, suitable means of waste disposal, recovery, conversion, control and reuse (Olanrewaju and Ilemobade, 2009).

Environmental pollution created by polythene includes soil, water and air contamination and blocking of drains and sewage lines in and around cities. Since polythene is non-degradable, it remains intact in water and soil for many years, choking otherwise productive soil (Sharma and Kanwar 2007). Adverse effects on livestock have also been reported (Mohammed and Muhammed 2007). Open burning of refuse dumps in developing countries is a common practice (Izugbara and Umoh 2004). It has been realized that if burnt, polythene, produces harmful toxins which can threaten air quality (UNEP 2002; Sharma and Kanwar 2007). Some of the toxins released include pops such as hazardous dioxins (UNEP 2002). Other thermal/oxidative degradation products of polythene have been studied in controlled conditions and consist of chemicals that are harmful to human health (Sojaka et al. and others, 2006).

During construction, there is a necessary demand for the excavation of the entire area needed for sub-structure (foundation) and, in same cases (e.g. road construction) the cutting of the vegetable soil which is not a good engineering material. It is often the case that such excavation works become more challenging in areas with buried. polythene waste because of soil hardening due to chemical constituents present in the polythene material. Polythene waste does not allow for a complete compaction and consolidation of the soil which then reduce its bearing and shearing strength(Awomeso et al. 2010).

METHODOLOGY

Two major approaches were adopted in acquiring the data used in this study. A daily market, the Akpan Andem market in Uyo (capital city of the state) was selected for data collection. Two areas, measuring 10m x 30m each were demarcated in such a manner that one was in the raw food section and the other in the processed food items (provision stores) section. In the market, one of the sanitation personnel was made to sweep the demarcated areas daily and was instructed to always select the cellophane from other wastes. Polythene waste products were then stored in special refuse collection bins and measured weekly. And because it was also within the scope of this study to determine and compare the amount of cellophane generated at homes and in the market, 100 waste paper baskets were distributed to 50 respondents who participated in the study. Each participant was given 2 waste paper baskets. While one of these baskets was placed and, monitored in the market, the other was used at the participant's home. Data were collected on weekly basis in the months of July and November 2010, and analyzed using percentage and bar charts. This study concentrated only in the market and at homes because these are the major polythene waste generation areas.

The following procedures of recycling polythene materials were adopted:

(i) Inspection – polythene wastes were inspected for contaminants such as rock and glass and for materials that the plant can not recycle.

(ii) Chopping and washing – the polythene wastes were washed and chopped into flakes using the washing machine as shown in Fig. 2.

Fig. 2. Washing machine

(iii) Flotation tank – If mixed polythene were being recycled, they were sorted in flotation tank, where some types of polythene sink and others float. The floatation unit is shown in Fig. 3

Fig. 3 **Floatation unit**

(iv) Drying – The polythene flakes were then dried in a tumble drier as in Fig. 4.

Fig. 4. Drying machine

(v) Melting – The dried flakes were fed into an extruder where heat and pressure melt the polythene. The extruding machine is shown in Fig. 5. Different types of plastic melt at different temperatures.

Fig. 5. Extruding machine

(vi) Filtering – The molten polythene were forced through a fine screen to remove any contaminants that slipped through the washing process. The molten plastic was then formed into strands.

(vii) Pelletizing – The strands were cooled in water, using the cooling bay as in Fig. 6. They were then chopped into uniform pellets using the palletizing machine shown in Fig. 7, and manufacturing companies buy the plastic pellet from recyclers to make new products.

Fig. 6. Cooling bay

Fig. 7. Pelletization machine (top) and Product (bottom)

RESULT AND DISCUSSION

The polyethylene material collected were sorted and counted. The result showed that pure water sachet topped the list, followed by ice cream and biscuit wrappers (Table 2 and Fig. 8). Pure water sachet topped the list because it is consumed throughout the year, Again, the studied market has no public potable water system where the traders can get their drinking water. As a result, majority of them depend on the sachet water on a daily basis. Some traders who take their drinking water to the market from homes soon discover that the water becomes too warm and unfit for consumption in the afternoons, particularly in the dry season. Consequently, they resort to the cold sachet water that is being hawked all over the market.

Ice cream wrappers exhibited the highest variation in this study. Their generation and disposal are readily compared both during the dry months and during the heart of the wet season. Polyethylene for assorted items also exhibited high seasonal variation. This implies that its demand and consumption are almost uniform throughout the year. Dede (2000) reported similar finding for Ibadan and noted that among the non-biodegradable solid waste generated, cellophane is mostly affected by seasonality.

Types of cellophane generation at home and market also displayed a very interesting pattern (Table 1 and Fig. 8). In ascending order, it shows that polyethylene for assorted items was the least (51.000 kg), followed by biscuit (56.865kg), ice cream sachets (81.526kg) and table water sachets (96.361kg) in the market. At home, the trend displayed, when arranged in closely followed by biscuit wrapper (45. 263kg), ice cream wrappers (35.514kg) and pure water sachets (25.360kg). Cellophane for assorted items ranked lowest in the market because they are used in wrapping items in the market but disposed off at home having removed the contained items for cooking or storage. The generation of pure water sachet was lowest at home but highest in the market. This is so because most homes have refrigerator where they can store water for it to get cool/cold. The findings is in agreement with Tanko's (2001) study in Yola, Northern Nigeria, where he reported that cool sachet water and ice cream are sold more at markets and schools. The mean number of individual polyethylene generated was also examined. Further analysis showed that an individual generated and disposed 0.665kg of cellophane daily (Table 2).

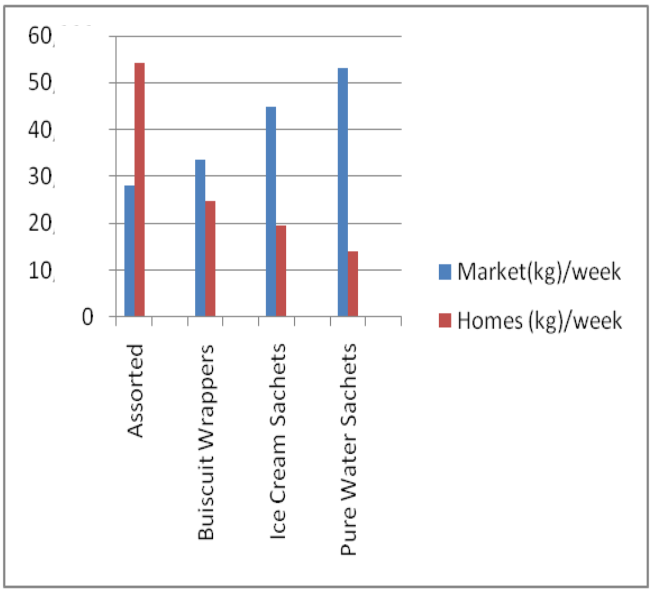

Fig. 8a. Bar chart showing polyethene waste generated at homes and market during dry season month, Nov. 2010.

Table 1. Comparison between polyethylene wastes generated seasonally at home and market
(a) dry season month of November 2010

Place / Types	Assorted	Biscuit wrappers	Ice cream sachets	Pure water sachet
Market (kg)/week	28.050	33.475	44.859	52.998
%dry at the market	9.9	11.55	15.4	18.15
Homes (kg)/week	54.099	24.895	19.533	13.948
% dry at homes	26.96	12.1	9.35	6.6

(b). wet season month of July, 2010

Place / Types	Assorted	Biscuit wrappers	Ice cream sachets	Pure water sachet
Market (kg)/week	22.950	27.388	36.703	43.362
% wet at the market	8.1	9.45	12.6	14.85
Homes (kg)/week	44.262	20.368	15.981	11.412
% wet at homes	22.05	9.9	7.65	5.4

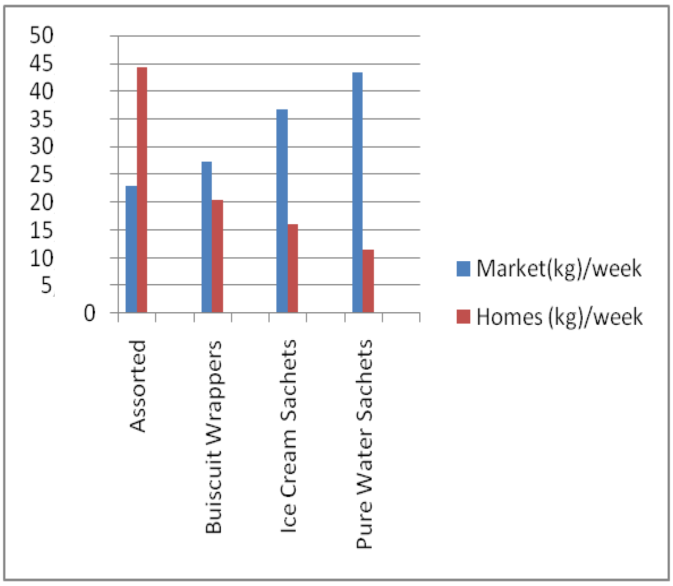

Fig. 8b. Bar chart showing polyethene waste generated at homes and market during wet season month, July 2010

Table 2. Measured and estimated amount of polyethylene generated by individual in Uyo, Akwa Ibom State and Nigeria

Category	Estimated population (m)	No. of polyethylene/week
Individual	individual	0.665kg
Total for Uyo	1.2 million	1.4 million
Total for Akwa Ibom State	3.92 million	2.53 million
Nigeria	140 million	9.31 million

Measured estimated source: *Field work 2010*

Using the data of Table 2 one can imaginge the large volume of cellophane being generated and disposed in Nigeria in its environmental context. The questionnaire survey further revealed that 82% of the respondents prefer the use of polyethylene as wrappers than natural leaves because they are relatively cheaper and with higher aesthetic value. Only about 15% of the respondents showed preference for local leaves as wrappers and these were mainly the aged ones.

Recycled polyethylene

Plastic pellets resulting from processing of the polyethylene wrappers (Fig. 7) were used for the production of new poly-bags of HDPE, MDPE or LPDE characteristics.

- HDPE (high density polyethylene Fig. 9) has a density of greater than or equal to 0.941g/cm^3. It has a low degree of branching and thus stronger intermolecular forces and tensile strength. It is used in products and packaging such as milk jugs, detergent bottles, margarine tubes, garbage containers and water pipes.

Fig. 9. High Density Polyethylene (HDPE)

- MDPE (medium density polyethylene) is marked by a density range of 0.926 – 0.940g/cm^3 and can include chromium/silica catalysts. It has a good shock and drop resistance properties and is also less notch sensitive than HDPE. It is used for the production of gas pipes and fitting sacks, shrink film, packaging film, carrier bags and screw closures.
- LDPE (Low Density Polyethylene Fig.10) is characterized by a density range of 0.910 – 0.940g/cm^3. It has a high degree of short and long chain branches and the chains are weakly packed into the crystal. It has less strong intermolecular forces as the instantaneous – dipole induced-dipole attraction is less. This result in a lower tensile strength and increased ductility. LDPE is created by free radical polymerization and is used for both rigid containers and plastic film application such as plastic bags and film wrap.

Fig. 10. Low Density Polyethylene (LDPE)

Master batch polyethylene (Fig.11) was also produced from the recycling presses. This is a coloured polyethylene in pellet form. It is used for the determination of a particular colour of a poly-bag at the ratio of 1:25 and its density is 0.940g/cm^3.

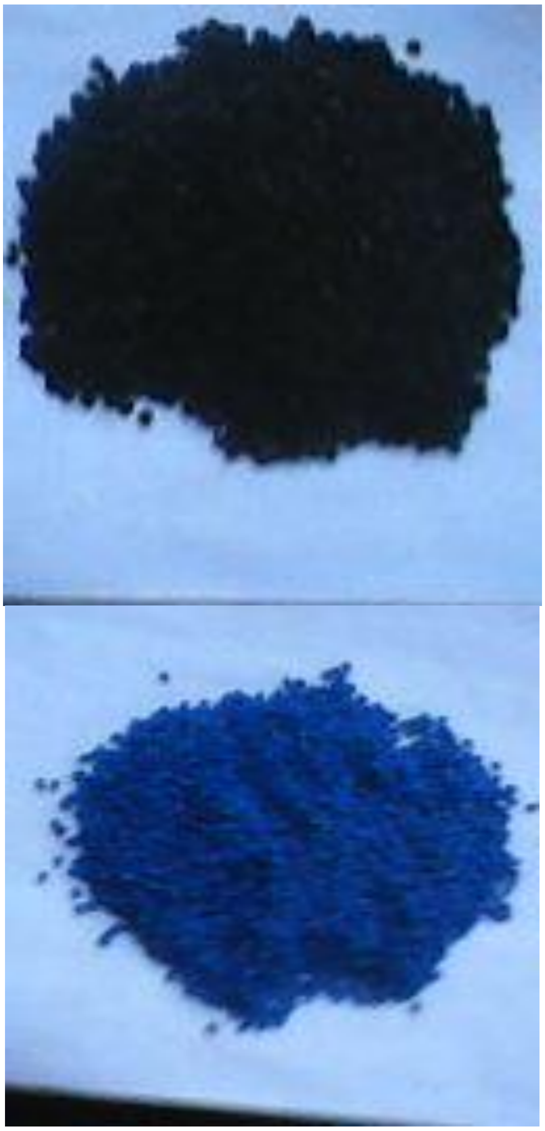

Fig. 11. Master batch polyethylene: Black (top) and Blue (bottom)

CONCLUSION

Polyethylene waste generation was found to be higher during the dry season months (November – March) than the wet season months (April – October) with the least in the month of June. None foodstuff markets dominated by male traders who depend solely on wrapped food items with polyethylene had the highest cellophane generation. Cellophane generation was also higher in the markets than at homes. This is so because at homes, most food is served with plates and the consumption of pure water and ice cream are considerably reduced. A larger proportion of the respondents prefer the use of polyethylene as wrappers, to newspaper and natural leaves because of its cheapness, neatness and readily availability. Generally, respondents use polyethylene for shopping.

Polyethylene is a major source of environmental degradation in Nigeria, and this form of environmental abuse is worse in the urban areas. For a cleaner and sustainable environment therefore, massive awareness campaign and enlightenment about the danger cellophane poses to our environment should be vigorously carried out. Government should provide public waste bins mainly for polyethylene materials in strategic positions for the collection of this waste.

The government and individual should consider the recycling option of polyethylene material as the best option of treating its waste.

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