ISSN NO. 2320-5407

Journal homepage: http://www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH

RESEARCH ARTICLE

THE POTENTIALS OF PLASTIC WASTES RECYCLING IN MAIDUGURI METROPOLIS

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Manuscript Info

Manuscript History:

Received: 15 June 2015
Final Accepted: 26 July 2015
Published Online: August 2015

Key words:

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Abstract

One of the greatest environmental challenges that is confronting Maiduguri metropolis in Borno State – Nigeria is the fact that there is ever increasing disposals of plastics after used into the waste stream which of course cannot decompose even if buried in the ground making our farm lands not suitable for farming purposes and also causing environmental pollution. Owing to approximately 481 tons of plastic bags brought into Maiduguri every year excluding those produced by plastic companies within the metropolis and plastic containers, which of course are disposed off after used and generally the effects of plastic wastes which relates to its disposals such as habitats for rodents, odours, suffocation and eventually death when swallowed by animals, hence, the need to investigate the potentials of plastic waste recycling in Maiduguri metropolis.

This study was conducted to investigate the effects of disposing plastic wastes in landfills, the economic importance of recycling plastic wastes and techniques for plastic waste management. Plastic waste samples were collected from industrial and municipal wastes of Maiduguri metropolis for recycling purpose.

From the recycling process conducted and the result obtained, 105kg of plastic scraps, packaged water bags and plastic film bags were collected from municipal wastes and recycled with approximately 90.36kg plastic pellets reclaimed. Also, 85kg of black film bags and white thick bags were collected from industrial waste in which approximately 81.22kg pellets were reclaimed. These figures give a total of 90.31% recycling efficiency from a total of 190kg of plastic wastes collected with 171.58kg recovered. Therefore, from the results obtained, plastic wastes recycling in Maiduguri metropolis should be encourage which has the potentials of boasting the economic sector, job creation for unemployed youths and most importantly tackling environmental and health hazards posed by the high presence of plastic wastes send to waste stream after used which cannot decompose.

INTRODUCTION

Plastics are polymers which have been modified by virtue of additive or bulk fillers which are incorporated in the base polymer resin for ease of processing, enhancement and stability of properties or economics. There are wide variety of them and are finding ever increasing use in our daily lives. (Ibhadode, 2001). The world's annual consumption of plastic materials has increased from around 5 million tons in the 1950s to nearly 100million tones today. In the UK, a

total of approximately 4.7 million tones of plastics products were used in various economic sectors in 2001 (Parfiffs, 2002).

TYPES OF PLASTICS

There are about 50 different groups of plastic, with hundreds of different varieties. All types of plastic are recyclable. To make sorting and thus recycling easier, the American society of plastics industry developed a standard marking code to help consumers identify and sort the main types of plastic. These types and there most common uses are:

1. **PET Polyethylene terephthalates** – tizzy drink bottles and oven-ready meal trays.
2. **HDPE High Density Polyethylene** – Bottles for milk and washing up liquids.
3. **PVC Polyvinyl Chloride** – food trays, cling film, bottles for squash, mineral water and shampoo.
4. **LDPE Low Density Polyethylene** – carrier bags and bin liners.
5. **PP Polypropylene** – margarine tubs, microwavable meal trays.
6. **PS Polystyrene** – yoghourt pots, foam meat or fish trays, hamburger bores and egg cartons, vending cups, plastic cutlery, protective packaging for electronic goods and toys.
7. **Other** - any other plastic that do not fall into any of the above categories. An example is melamine, which is often used in plastic plates and cups.

The advantages of plastics include their low density, high resistance to chemical attack, thermal and electrical insulation properties, and ease of fabrication into a variety of shapes both simple and complex and their drawbacks include low strength, and elastic modulus values, when compared with metals, low softening and thermal degradation temperatures and their relatively high thermal expansion coefficient. However, when they are combined with material (fillers) into composites, they can be used satisfactorily for applications which are subjected to moderate loads. (Ibhadosde, 2001).
One ton of plastics is equivalent to 20,000 two liter drinks bottles or 120,000 carrier bags. (LINPAC, 2001)

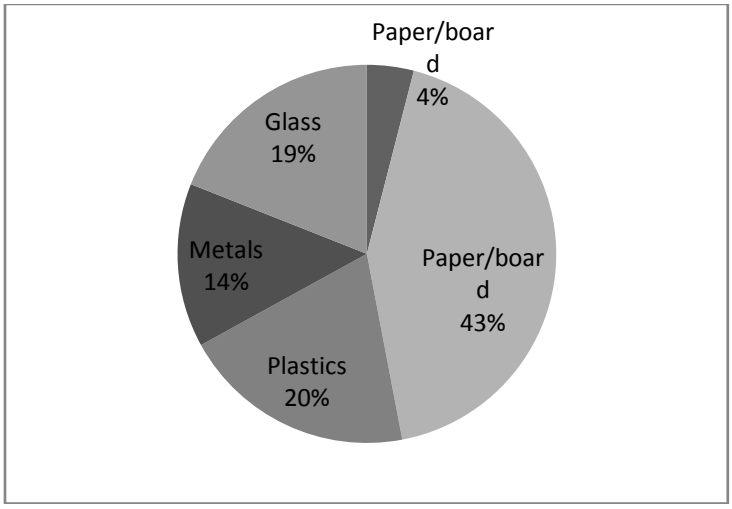
Plastics play an important role in almost every aspect of our lives. Plastics are used to manufacture everyday products such as beverage containers, toys, and furniture. The wide spread use of plastics demands proper end life management. Plastics make up almost 13 percent of the municipal solid waste stream, a dramatic increase from 1960, when plastics were less than one percent of the waste stream. (US EPA, 2013.)

The largest amount of plastics is found in containers and packaging (e.g. soft drink bottles, lids, shampoo bottles), but they also are found in durable (e.g. appliances, furniture) and nondurable (e.g. diapers, trash bags, cups, utensils and medical devices).

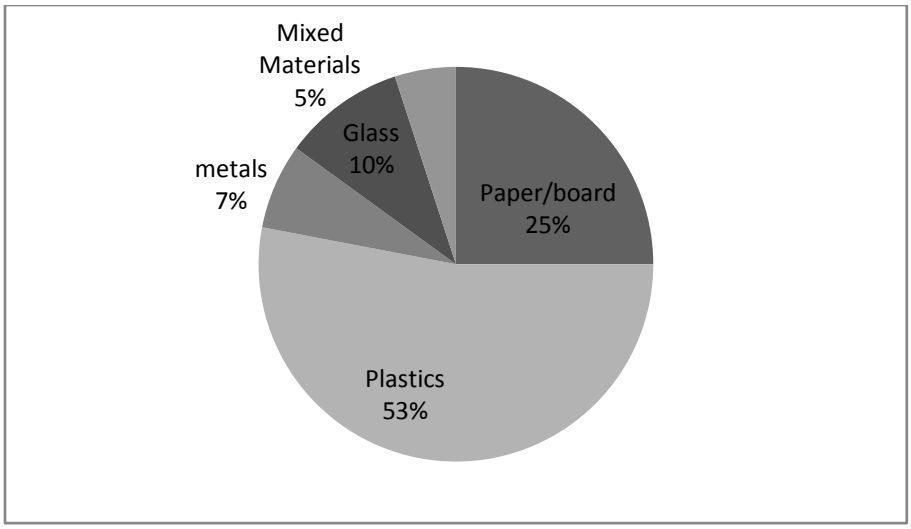
Packaging materials

The most common types of materials used for packaging are paper, board, plastic, glass, steel and aluminum.

Chart 1. Weight of packaging materials %



Chasrt 2. Percentage of packaged goods



Source: INCPEN toward greener households June, 2001

Plastic packaging accounts for 20% of the weight of all packaging and 53% of all goods are packaged in plastics as shown in charts 1 & 2 above. Because of its low weight and relative strength, plastic is one of the most energy efficient, robust and economic delivery methods available (INCPEN, 2001)

1.0 HOW PLASTICS ARE MADE

Plastics can be divided into two major categories thermosets and thermoplastics.

A thermoset solidifies or "sets" irreversibly when heated. They are useful for their durability and strength and are therefore used primarily in automobiles and construction applications. Other uses are adhesives, inks, and coatings.

A thermoplastic softens when exposed to heat and returns to original condition at room temperature. Thermoplastics can easily be shaped and molded into products such as milk jugs, floor coverings, credit cards, and carpet fibers.

In a year some 100millions tones of plastic wastes are generated from industrials, commercial and household source alone. The biggest problem with waste relates to its disposal rather than the volume involved. Around two-third of these plastic waste is currently conveyed to landfills sites for disposal. Open site dumping of waste is associated with problems: firstly, the land fill space is becoming increasingly scarce having in mind the ever increasing world population of about 6 billion at present, hence odours, rodents and a lot of disease, are waste related.

Secondly, plastics are highly poisonous and are dangerous to health as they can cause suffocation and even death when swallowed by animals.

1.1 WHY PLASTIC RECYCLING

Recycling means to reuse a material that would otherwise be considered waste. The popular meaning of recycling in developed countries has come to refer to the wide spread collection and reuse of waste materials.

According to US EPA 2013, the recycling rate for different types of plastics varies greatly, resulting in an overall plastics recycling rate of only 9 percent, or 2.8 million tons in 2012. However, the recycling rate for plastic products is much higher, for example in 2012, 28 percent of HDPE bottles and 31 percent of PET bottles and jars were recycled.

A study carried out on four of the registered companies producing polyethylene bags in Maiduguri, Jos, Kano and Lagos shows that they all produce an average of 214.2 tons of polyethylene bags per annum. The total number of companies producing polyethylene bags in Nigeria is 32. By multiplying the average value per annum with 32, gives 1854.4 tons of polyethylene bags produced in Nigeria every year. (Akinola and Jenkins, 1997).

In Maiduguri however, studies shows that 9.25 tons of polyethylene bags are brought into the metropolis weekly making a total of 481 tons per annum. Of course these polyethylene bags will be disposed off after use. Such bags are found in open spaces in Maiduguri in such areas of police barracks, Ramat shopping complex, Bulabulin, on Campuses behind the Juma' at mosque and others (shuiabu, 2004)

Therefore, action to reduce wastes, either by encouraging material efficiency, reducing the generation of wastes or enabling the recovery and reuse of discarded material, is a critical element of sustainable development.

Recycling plastic waste is an essential part of national waste prevention and waste system strategy. Recycling plastics that may otherwise be diverted to landfills, incineration, or roadside litter is a positive step in reducing the waste stream and should be reported in all programmes for solid waste management.

Research engineering specifications, government regulations and continued interest are necessary for future success of the products made from recycled post consumer plastics. (Mc Grew Hill, 2002).

Plastic can be and are currently being processed at both manufacturing and post consumers levels. The processed resin can then be blended with virgin resin to enhance its properties.

2.2 ENVIRONMENTAL BENEFITS

A report on the production of carrier bags made from recycled rather than virgin polyethylene concluded that the use of recycled plastic resulted in the following:

- Reduction of energy consumption by two-thirds
- Production of only a third of sulphur dioxide and half of nitrous oxide.
- Reduction of water usage by nearly 90%
- Reduction of carbon dioxide generation by two-and-a-half times

A different study concluded that 1.8 tons of oil are saved for every tone of polythene produced (Parfitt, 2002).

Recycling plastic can have several other advantages:

- Conservation of non-renewable fossil fuels – plastic production uses 8% of the world's oil production, 4% as feedstock and 4% during manufacture.
- Reduced consumption of energy
- Reduced amount of solid waste going to landfills
- Reduced emission of carbon dioxide (CO_2), nitrogen-oxide (NO) and sulphurs–dioxide (SO_2).

2.3 SOURCES OF PLASTIC WASTES

According to Lardinoiss, 1995, the sources of plastic waste include:

1. **Industrial waste:**
   Industrial wastes can often be obtained from few plastic processing, manufacturing and packaging industries. Rejected or waste materials usually have good characteristics for recycling and will be clean.

2. **Commercial waste:**
   Commercial waste is often available from workshops, craftsman shops, super markets and wholesalers. A lot of the plastic available from this source will be polyethylene.

3. **Agricultural waste:**
   Agricultural waste can be obtained from farms and nursery gardens outside the urban areas. This is usually in a form of packaging (plastic containers or sheets) fertilizer bags, construction materials (irrigation or hose pipes) etc.

4. **Municipal waste**

Municipal waste can be collected from residential areas (domestic or household waste), streets, parks, collection depots and waste dumps.

2.4 PROCESSING WASTE PLASTICS

1. **Initial upgrading**

Once a plastic had been collected, it will have to be cleared and sorted. The techniques used will depend on the scale of operation and the type of waste collected, but the simplest level will involve hand washing and sorting of plastics into required groups. More sophisticated mechanical washers and solar drying can be used for larger operations. Sorting plastics can be polymer type (thermosetting or thermoplastic), by products (bottles, plastic sheeting etc.), by colour etc.

2. **Size reduction**

Size reduction is required for several seasons to reduce large plastic wastes size to a size manageable for small machine, to make the material denser for storage and transportation or to material denser for storage and transportation or to produce a product which is suitable for further processing. There are several techniques commonly used for size reduction of plastics. Some techniques commonly used for size reduction of plastics;

- **Cutting**

Cutting is usually carried out for initial size reduction of large objects. It can be carried out with pair of scissors, shears, saw etc.

- **Shredding**

Shredding is suitable for smaller pieces. A suitable shredder has a series of rotating blade driven by an electric motor, some form of grid for size grading and a collecting bin. Materials are fed into the shredder via a hopper which is cited above the blade rotor. The product of shredding is a pile of coarse irregularly shaped plastic flakes which can then be further processed.

- **Agglomeration**

Agglomeration is the process of pre-plasticizing soft plastic by heating, rapid cooling to solidify the material and finally cutting into small pieces. This is usually carried out in a single machine. The product is coarse, irregular grain, often called crumbs.

3. **Extrusion and pelletizing**

The process of extrusion is employed to homogenize the reclaimed polymers and produce a material that is subsequently easy to work. The reclaimed polymer pieces are fed into the extruder, are heated to induce plastic behavior and then forced through a die to form plastic spaghetti which can then be cooled in a water bath before being pelletized. The pelletisation process is used to reduce the spaghetti to pellets which can then be used for the manufacture of new products.

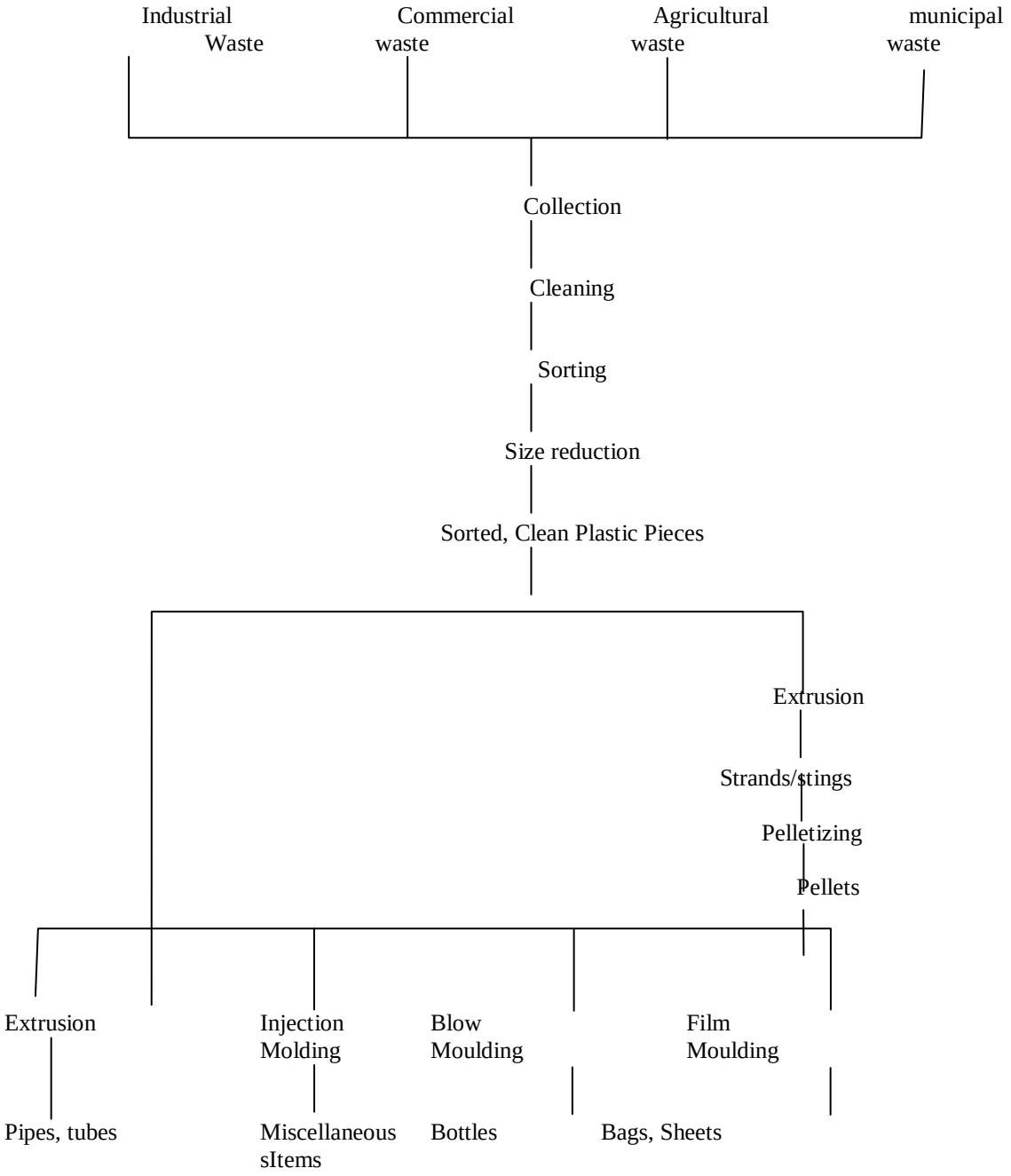


Fig2.1. Flow chart of a typical waste plastics reprocessing stream in a low-income country (Tool, 1995)

3.0 MATERIALS AND METHOD

3.1 The Study Area

Borno State has a total land mass of 69,435sq.km and lies between latitude $11^0$50'N and Longitude $13^0$09'E. The greater part of the state lies on the Chad basin. It is bounded to the west by Yobe state, to the north by Niger and Chad republics and to the east by Cameroun republic while to the south by Adamawa and Gombe States. (NPC, 2006).

Maiduguri is the capital of Borno State. It is located in the Sahel Savannah region of north-east Nigeria at latitude $11^0$05'North and longitude $13^0$05'East and about 350m above sea level. It occupies an area of 50,778 square kilometers. It is the largest city in North-Eastern Nigeria bordered by the republic of Niger to the north, Chad to the north-east and Cameroun to the east. The population of Maiduguri was estimated to be 1,197,497 (NPC, 2007).

The city has several tertiary institutes including University of Maiduguri, Ramat Polytechnic, College of Education, College of Agriculture, Mohammed Goni College of Legal and Islamic Studies among others. Maiduguri has several tourist attractions such as the Shehu's palace, and museum which present collections from the history of Borno, the zoo (Kyarimi Park) and Lake Alau.

3.2 METHODOLOGY

The research work is intended to take this form:

i. Collect samples of plastic wastes
ii. Evaluate the amount of recyclable
iii. Recycle to know the percentage reduction of plastic waste generation.
iv. Come out with a policy of submission for eventual implementation to the government, highlighting the problems and benefits of this research work and its non-consideration.
v. To know the amount which has been recycled: the percentage of recycled versus the original material.

3.3 MATERIAL COLLECTION

Eight (8) samples of plastic wastes were collected of which three samples were from factory and five samples were from the waste stream for recycling to know the percentage of waste reduction from the plastic wastes sent to landfills on daily basis. The various samples and the quantities collected are described in the table below:

3.4 METHODS

3.4.1 Cleaning/sorting

Depending on the scale of operation, the process in this research involved hand washing and drying under the sun. But mechanical washers are used for larger scale operation. Sorting out non-recyclable material that might have been collected together with the samples is done manually.

3.4.2 Size Reduction

In order to reduce larger plastic scraps to sizes manageable for small machines and for easy transportation, the size reduction operation involves the use of scissors, saw and shears. Mechanical shredders are used when operating a plastic factory.

3.4.3 Extrusion and Pelletizing

The extrusion operation was carried out on the samples collected. The samples were heated in the extruder to induce plastic spaghettis, which were then cooled in water bath before being pelletized. The pelletizations process reduces the plastic spaghetti to pellets, which are used for new products manufacturing.

3.5 PRODUCT FROM RECYCLED PLASTIC WASTES:

Secondary materials are products recovered from waste stream. A variety of secondary materials are produced from plastic waste. These includes flowers pots, garbage bags, paints brushes, carpet fibers, fiber fills for jackets, toys and a lot more which could not be mentioned.

3.6 PERCENTAGE OF MATERIALS RECOVERED

Sample A. $\frac{24.10}{25.00}$ x 100 = 96.4%

Sample B. $\frac{38..24}{40.00}$ x 100 = 95.6%

Sample C. $\frac{18.88}{20.00}$ x 100 = 94.4%

Sample D. $\frac{16.87}{20.00}$ x 100 = 84.4%

Sample E. $\frac{8.61}{10.00}$ x 100 = 86.1%

Sample F. $\frac{8.57}{10.00}$ x 100 = 85.7%

Sample G. $\frac{8.76}{10.00}$ x 100 = 87.6%

Sample H. $\frac{45.55}{55.00}$ x 100 = 86.5%

4.0 RESULT PRESENTATION

sample	Description	Quantity (KG)	Remark
Sample A	White Film Bags	25	Factory
Sample B	White Thick Bags	40	Factory
Sample C	Black Film Bags	20	Factory
Sample D	Pure Water Bags	20	Waste Stream
Sample E	Black Film Bags	10	Waste Stream
Sample F	White Film Bags	10	Waste Stream
Sample G	Yellow/Black Striper Bags	10	Waste Stream
Sample H	Plastic Scraps	55	Waste Stream

Table 3.1 Samples of waste collected

Fig.3. 1 Shows the some samples of waste collected from the waste stream

Samples	**Mass collected (kg)**	**Mass wasted and squeezed**	**Mass dried (kg)**	**Mass obtained after shredding (kg)**
Samples D	20	18.62	17.50	16.87
Samples E	10	9.14	8.89	8.61
Samples F	10	9.24	8.78	8.57
Samples G	10	9.29	8.97	8.76
Samples H	55	52.31	50.53	47.55

Table 1.2 shows the value obtained after cleaning, sorting, washing and shredding from the samples collected from waste stream

Samples	**Mass Collected (kg)**	**Mass Recycled (kg)**	**Mass of Waste Generated (kg)**

Samples A	25	24.10	0.90
Samples B	40	38.24	1.76
Samples C	20	18.88	1.12

Table 1.3 Shows data obtained from recycling samples collected from factory waste.

Fig 3.2 Mixed materials recovered from plastic waste

Fig. 3.3 shows samples of pellets obtained from the black films reclaimed

The summary of result obtained from this piece of research work is shown in the tables below:

Samples	Quantity Collected (kg)	Quantity Recovered (kg)	Percentage of Recovered Material (%)
Sample A	25.00	24.10	96.4
Sample B	40.00	38.24	95.6
Sample C	20.00	18.88	94.4

Table 4.1 Shows summary of the results obtained in the recycling of the industrial waste collected.

Samples	Quantity Collected (kg)	Quantity Recovered (kg)	Percentage of Recovered Material (%)
Sample D	20.00	16.87	84.4
Sample E	10.00	8.61	86.1

Sample F	10.00	8.57	85.7
Sample G	10.00	8.76	87.6
Sample H	55.00	47.55	86.5

Table 4.2 Shows summary of the results obtained from recycling municipal wastes collected.

4.1 DISCUSSION OF RESULTS/VALUES

The identified sources of plastic wastes in Maiduguri metropolitan include:

- Household
- Commercial
- Industrial
- Institutional etc.

This research work restricted it findings to industrial plastic wastes (collected directly from production line) and municipal plastic wastes (collected from residential area, streets, parks, collected depots and waste dumps).
The approximate quantity of waste collected was 190kg with 171.58kg recovered. This give us 90.31% recovery of what otherwise could be sent to waste stream.

Therefore, the results show that the vast tons of plastic materials brought into and manufactured in Maiduguri metropolis every year which will eventually be disposed into the waste streams after used could be reduced by 90% if plastic wastes recycling plants are set up in the metropolis this would not only reduced quantity of wastes generated, it will also create jobs for the teeming number of un-employed youths and also add value to the economy of the state and the nation at large.

However, there was a variation of approximately 10% increase of the material recovered from the industrial plastic wastes from that of the municipal plastic wastes collected during this research work due to the fact that unlike the industrial wastes, the municipal plastic wastes were collected directly from waste dumps, streets, waste collection depots etc. which of course have dirt's and are mixed up with some unwanted materials.

Moreover, some problems encountered in the cause of this research includes, plastic wastes are very dirty, differences in melt index, labels on plastic materials, screw and bolt joints and shrink, metal inserts, many brands, structures that cannot be cleaned etc.

4.2 IMPACTS OF PLASTIC WASTES RECYCLING

1. Waste reduction in our environment
2. Reduced environmental problems like, odours, rodents etc.
3. Boost our farming sector as its presence in our environment makes the soil not suitable for farming purpose.
4. Conservation of the depleting mineral resources as the reclaimed material is used instead of the virgin resin in some plastic products.
5. An insight of waste management scheme
6. Stop creating nuisance and hazard to the public health and safety.

5.0 CONCLUSION

It was found out that about 481tonnes of plastic bags are brought into Maiduguri metropolis every year excluding those produced by plastic companies, within the metropolis and other plastic container. Of course, these are disposed off after used and with such quantity; possible means of recycling them into new products should be a point of concern in Maiduguri.

For recycling process to become successful, the following requirements should be met.

1. A continuous and reasonable source of plastic waste is available.
2. There should a ready market for the recycled product and
3. Technology must be there for sorting, cleaning and size reduction of the plastic scraps.

4 RECOMMENDATION

Recycling plastic wastes is an essentials part of solid waste management. Based on this research work, the following recommendations are proposed.

1. Collection of the plastic items and eventually separation by the users.
2. Developing communal plastic waste recycling

3. Legislation to boost recycling
4. Attitude change towards the bad reputations of waste recycling.

Furthermore, the table below suggests some alternative manufacturing process for plastic companies.

AVOID	**PREFER**
Many plastic brands	Same polymer waste minimization
Screw and bolt joints and gluing	Snap fits and welding
decorating	Covering
Labels	Laser marking
Metal inserts	Plastic inserts or soft metals
Integrate metal parts/engines	Assembly and dismantle friendly design
Structures that cannot be cleaned	Easy cleaning with dismantle parts
Not-marked plastic	Plastic marking

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