OPPORTUNITIES FOR RE-USE OF RECYCLED BEVERAGE CARTONS IN KENYA THROUGH PRODUCT DESIGN

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DECLARATION

I Richard K. Allela, declare that this project paper is my original work and has not been presented for the award of any degree in any other university.

Signed……………………………

Date………………………………

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The project is submitted in partial fulfillment of the university examination for the award of the degree of Bachelor of Arts and Design at the University of Nairobi.

Supervisor:  Dr. Maina S. Mwituria

Signed………………………………

Date………………………………
DEDICATION

I dedicate this project paper to my family for their belief in me and continuous support and to my dear mother for her selfless sacrifice to see me through school.
ACKNOWLEDGEMENT

In the course of preparation, research and completion of this project paper numerous people played a huge part in seeing it to the end. I would like to sincerely thank my supervisor for his guidance throughout the paper, my family for their moral and financial support, Mr. Chana of Ecotech Ltd for allowing me to use their facilities and to God Almighty for making everything possible.
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ABSTRACT

Beverage cartons are made of several laminated layers, including paper, aluminum and low density polyethylene. High amounts of non-wood materials and lack of knowledge on the manufacturing of the package has made recycling beverage cartons an issue for the paper industry. The demand for high-grade fibers for recycling, led paper mills to look for alternative solutions to produce paper. This paper aims to educate interested parties on various ways of recycling beverage cartons and its importance to environmental conservation.
CHAPTER ONE

1.0 INTRODUCTION

1.1 What are beverage cartons?

Aseptic beverage carton was invented by Tetra Pak over half a century ago to address a need to supply safe milk to young children in the post war era. Today, even as Tetra Pak supplies both packaging material and processing machine to customers in over 165 countries, the company remains focused on offering the highest level of food protection in the most resource efficient package.

Aseptic packaging can be defined as the filling of a commercially sterile product into a sterile container under aseptic conditions and hermetically sealing the containers so that reinfection is prevented. This results in a product, which is shelf-stable at ambient conditions. The term “aseptic” is derived from the Greek word “septicos” which means the absence of putrefactive micro-organisms.

1.1.1 Types of beverage cartons

All cartons are made mainly from paper. Gable-top (or refrigerated) cartons contain additional layers of plastic, while aseptic (or shelf-stable) cartons contain additional layers of plastic and aluminum. Cartons are designed to keep the product inside as fresh as possible, blocking out light and odors that may cause products to spoil. Aseptic cartons are made primarily of paperboard (75 percent) with thin layers of plastic (20 percent) and aluminium (five percent), allowing liquid food to be safely stored at room temperature without preservatives (Tetra Pak 2007). One of the leading companies to produce these cartons is Tetra Pak.
Each material provides a specific function:

- **Paper (80%)**: to provide strength and stiffness

- **Polyethylene (15%)**: to make packages liquid tight and to provide a barrier to microorganisms

- **Aluminium foil (5%)**: to keep out air, light, and off-flavours - all the things that can cause food to deteriorate

### 1.2 Background of the problem

Growing populations, rising incomes, and changing lifestyles contribute to severe waste management problems in many urban centers around the world (UNEP-IETC HIID 1996). In low-income countries, a majority of municipal solid waste is inadequately processed. This leads to serious environmental problems that affect the health of humans and animals and cause economic and welfare losses. These impacts take the form of contamination of surface
and ground water through leachate, soil contamination, air pollution through open air incineration of waste, and spreading of diseases by vectors such as rodents (Zurbrügg, 2002).

Nairobi, the capital of Kenya, is a sprawling city of approximately 4 million people that is located on the eastern part of Africa. The constant influx of people from all over the country has created severe waste management problems in the city. While some of the waste is processed to landfills by the City Council, a lot of it is burnt at transfer points, on blocks of land, and in front of household premises. This creates smoke and odor impacts on surrounding areas. Some of the waste is dumped in unauthorized areas and some ends up in rivers, contributing to flooding in the city during the rainy season, as well as pollution of rivers and coastal waters.

In response to corporate commitments to environmental sustainability, along with new legal requirements on waste management, several large firms in Kenya are looking at ways to reduce the waste created from the discarded packaging of their products. Tetra Pak Group, a global leader in the production of beverage cartons, has been especially proactive in exploring and setting up recycling systems for its products around the world.

1.3 Problem Statement

The case against packaging, the sense that it creates growing amounts of needless waste, needs little elaboration. Not all packaging, unfortunately, is properly discarded or recycled. Some of it ends up littered on streets, public spaces, and rural areas. It does, however, appear to be quite salient, and troubling to concerned citizens everywhere. The mix of materials in aseptic packages creates composting problems. Aluminum foil and polyethylene are non compostable thereby posing a threat to the environment if not recycled. The aluminum foil in
the aseptic box will not combust and will end up as a residue in the ash.

In Africa most countries do not have the adequate resources to recycle these packages. The best that has become of the packages in Africa is children converting the milk cartons to toy cars used during playtime.

The damage done by waste beverage cartons includes, most obviously, its ugliness. Many people go to great lengths and expense to visit parks and beaches that are litter-free, providing indirect evidence of the importance of the aesthetic dimension of litter. But there are also more direct, physically damaging impacts of litter to consider. Litter does create real health and safety hazards when it piles up in an unsanitary manner.

1.4 Research questions

i. What are the different types of beverage carton waste in Nairobi?

ii. Which companies carry out recycling of beverage companies locally?

iii. Is the current technology for recycling of beverage cartons at par with those in developed countries?

iv. Is there an opportunity for re-use of recycled packaging waste materials in product design to minimize environmental degradation?

1.5 Aims and Objectives

This project aims at using design solutions to utilize beverage carton waste by incorporating innovativeness with already existing solutions in an economically, socially and environmentally viable way. Certain objectives arise from this aim:

- Determine any existence of beverage carton recycling programmes.
• Establish the benefits of recycling of beverage carton waste economically, socially and environmentally.

• To determine innovative incorporation of other recycled solid waste hence be an avenue for solid waste management.

• Establish various creative and innovative possibilities of using brecycled beverage cartons for designing functional products.

1.6 Scope

The research will be based in Nairobi due to its proximity to the researcher. Nairobi is also prone to solid waste management problems, hence the availability and accessibility of the research problem.

The research will also be carried in Ecotech limited, Industrial Area with reference to aseptic beverage cartons recycled from tetrapak waste.

1.7 Significance of the study

Packaging plays a valuable, often resource-conserving role in the modern distribution of food, beverages and other goods, and to maintain that a large and perhaps growing fraction of packaging is wasteful or environmentally problematical. There is need to learn how the packages once used can be recycled to create products that minimize environmental degradation and make economic sense both in terms of production and purchase. It is with this in mind that the researcher has undertaken this project to increase awareness on the benefits of recycling aseptic beverage cartons and to identify various products that can be made from the same.
1.8 Definition of terms

For the purpose of this project paper, the following definition of terms have been adopted and used in the context defined thereof;

**Aseptic** - The term “aseptic” is derived from the Greek word “septicos” which means the absence of putrefactive micro-organisms.

**Bleached Board** - Board made with pulp that has been bleached to a high level of brightness using chemical products. Bleaching is a whitening process carried out on pulps by selective chemical removal of residual lignin and other colored materials, and with minimal degradation of the cellulosic constituents.

**Hydrapulper** – Batch or continuous equipment for dispersing waste paper or Tetra Pak cartons in water to prepare papermaking stock. It is a big blender used in recycling plants with volume from 5 m³ up to 40 m³.

**Landfill** - This is a rubbish dump where waste materials are disposed by burying. Besides being disposal sites, some of them are used for other waste management purposes, such as the temporary storage, consolidation and transfer, or processing of waste material which pertains sorting, treatment or recycling.

**Linerboard** – Lightweight board used as the liners or facing for corrugated container. The main requirements are stiffness and strength.

**OCC** – **Old Corrugated Container** – Post-consumer packaging used as raw material to recycling mills to produce corrugated board.

**Pressure Screen** – Pulp screening equipment with some form of perforated barrier to remove oversize, troublesome and unwanted particles from good fiber.

**Pulp** - papermaking material existing in a disintegrated fibrous wet or dry state. Before it is dispersed onto the paper machine, it is mixed, beaten, and diluted to a suitable consistency for
fabrication of paper.

**Pyrolyses** – Chemical decomposition of the polyethylene by the action of heat.

**Rotary Drum – Rotary Screen – Trommel** – Coarse stock screen consisting of a large rotary shell fitted with perforated screen plates and having an internal spiral arrangement. It is installed in the reject exit of the pulper. Rejects enter at one end and the fiber is washed through the screen plates by high volume showers. The reject material travels to the opposite end of the cylinder (assisted by the spiral) where it is discharged. See figure 8.

**Wet Strength** – Chemical compounds used to avoid water penetration in the paper board.
2.0 LITERATURE REVIEW

2.1 Waste generation

Recycling saves energy, reduces raw material extraction and combats climate change. The vast majority of studies have found that recycling our rubbish is better for the environment rather than incinerating or land filling it.

Solid Waste Management is a major problem the world-over and in more so Kenya. In the world over several waste materials such as plastics, glass, metal, leather et cetera are dumped everyday. In Africa, plastics and electronic waste make up the bulk of the waste since most countries are not sufficiently equipped to recycle them. Solid waste offer several challenges from clogged drainage and sewers, waterborne diseases like typhoid, cholera and diarrhoea, increased upper respiratory diseases from open burning of the garbage to malaria.

Integrated Solid Waste Management (ISWM) also called sustainable solid waste management is a new concept of dealing with waste that is gaining currency in Kenya. Waste management has been the responsibility of local authorities but the scenario is changing with the realization that local authorities on their own are not capable of managing waste. Like other cities in the world, solid waste management is an expensive venture gobbling up to 30 to 50% of revenues (Zuben, Fernando, 2000). This is unsustainable hence Kenyan town and cities end up with endless heaps of garbage dotting the landscape.

One alternative waste management technique is the re-use of refuse. Waste recycling and re-use is often undertaken as a survival strategy when the urban poor are unable to obtain formal employment, and when non-waste resources are scarce or unaffordable. Waste re-use also plays a role in improving the urban physical environment. By reducing the total amount of solid waste headed for the landfill (or left lying to rot in the streets), recycling and
composting are land saving and pollution-reducing strategies. Waste re-use also plays a valuable resource conserving role: by recycling materials, further exploitation of scarce natural resources is minimized, thus containing the spreading ecological footprint of the city (Parfitt, 2002).

Despite these environmentally and socially beneficial aspects of waste recycling, it is not without its negative impacts, which include exploitation by waste buyers and poor health and living conditions for the urban poor who deal in waste picking.

The late Prof. Wangari Maathai founder of The Green Belt Movement and the first African woman Nobel Peace Laureate was a strong activist for environmental conservation. Maathai began to practice “mottainai” after learning the meaning of the word during a visit to Japan. Mottainai means “what a waste!” in Japanese. Wangari Maathai, who had been campaigning to reduce, reuse, and recycle for many years, decided to add the fourth R of repair because of a suggestion made by the head of the United Nations Environment Program (UNEP).

Maathai strived to make mottainai a global campaign in the future through The Green Belt Movement. According to a recent survey by UNEP, Nairobi with a population of 4.0 million generates 3,200 tons of waste daily. Only 850 tons reach Dandora dumpsite with the rest remaining unaccounted. To stem the problem, Nairobi with the help of both Japan International Cooperation Agency (JICA) and UNEP has developed a ten year Solid Waste Management Plan which the City Council of Nairobi plans to implement. This will involve urgent decommissioning of the Dandora dumpsite and building of sanitary landfill at Ruai in addition to two transfer stations. A further strategy involves building public-private-partnerships (PPP) including the use of community based organizations (CBOs) (Curran, 1993)

Introducing compulsory recycling is an effective measure for encouraging participation in
collection schemes, and has been found to require little or no enforcement to generate good results. The Nairobi City Council has introduced bins that have a specific section for biodegradable and non-biodegradable waste to encourage recycling of waste.

2.2 Beverage cartons manufacturing process

2.2.1 Raw Materials

Beverage carton are made from paperboard coated with a waterproof plastic, generally polyethylene. The wood pulp that is used to make paperboard for beverage cartons is a blend of softwood and hardwood. Softwood is usually a type of pine, though the actual trees used vary depending on the location of the paper mill. Softwood produces long wood fibers that provide strength to the paperboard. Hardwood comes from deciduous trees such as oaks. Hardwood has shorter fibers that make for a better printing surface. Pulp for milk carton board is usually 60% hardwood and 40% soft (Abreu, 2000).

Several other chemicals are used to make milk cartons. One is oxygenated chlorine, which bleaches the wood pulp. Other chemicals specific to each manufacturer are added to the paper to add strength. Chemical pigments in the ink are used for the printing process as well.

2.2.2 The Manufacturing Process

Making the paperboard

- The heavy paper used for beverage cartons is categorized as a type of paperboard. It is typically made on a Fourdrinier machine, one of the oldest and most common types of papermaking equipment.
The process begins with wood chips. The chips are heated and bathed in chemicals that soften them and break them into small bits of wood fiber.

The pulp is bleached in a bath of oxygenated chlorine.

The pulp is then washed and passed through several screens, to remove debris.

Next, the pulp is fed through a machine called a refiner, which grinds the wood fibers between rotating disks.

The refined pulp flows into the headbox of the Fourdrinier machine. In the headbox, a mixture of water and pulp is spread across a continually moving screen.

The water drains away below through the openings in the screen, leaving a mat of damp wood fiber. The mat is drawn through huge rollers that squeeze out additional water.

Next, the paperboard is dried, by passing it over steam-heated cylinders.

**Applying waterproof coating**

The dried paperboard next moves through the rollers of an extruder. As the paperboard is pulled through the rollers, the machine extrudes a small amount of molten polyethylene.

The polyethylene clings to both sides of the paperboard in a thin film. Several grades of polyethylene may be combined in the extruder, and the machine actually lays down multiple layers of film in one pass.

The different layers accomplish different tasks, such as reducing moisture penetration, reducing oxygen penetration, and aiding in essential oil retention.

As the paperboard comes through the extruder, it passes over a chilled roller, which cools both surfaces. The paper now has an extremely glossy, waterproof finish.
• It is wound into a large roll, to be transported to the printing area. The roll is typically 120 in (3.05 m) wide, too big to fit onto the printing and cutting machine. The large roll is slit into narrower rolls, the width determined by the desired dimensions of the finished carton.

**Printing and cutting the blank**

• Printing is usually done by the flexo-graphic method, which uses rubber printing plates attached to steel shells.
• Workers load the roll of polyethylene-coated paperboard into the press. The press prints the words and images of the milk carton onto the paperboard.
• A typical milk carton might be printed in anything from one to seven colors. All of the colors are printed at one pass through the machine.
• Next, the same machine scores the paperboard along what will be the edges of the carton, where the box will fold later. A die lowers, and stamps out the carton. If you cut open an empty milk carton down one side and across the bottom and unfold it, you can see the shape of the cut piece. This flat, scored, and printed piece is called a blank. The high-speed printing and cutting equipment turns out hundreds of blanks per minute.

**Sealing the blanks**

• Workers at the carton plant next load the blanks into a sealing machine. The machine takes the flat blank and folds it laterally, creating an overlapping side seam. The seam is then heated and squeezed together. The heated polyethylene bonds and the seam are strong and watertight without any additional glue.
Thousands of blanks per minute shoot through the sealing machine. This is the final step at the carton manufacturer. The sealed and folded blanks are loaded into corrugated cartons, and they are shipped.

**Forming and bottom-sealing**

- In the case that the beverage carton is used for milk, dairies use specialized machinery to transform the blanks into open containers. Workers first load the blanks into a chute leading into the forming machine.
- The blanks are pulled by suction down onto mechanical arms called forming mandrels. The forming mandrels snap the carton open along its scored lines, and overlap the two bottom flaps. The mandrels are aligned like spokes on a turning wheel.
- As the carton on Specialized machinery transforms the milk carton blanks into open containers. First, blanks are loaded into a chute leading into the forming machine. The blanks are pulled by suction down onto mechanical arms called forming mandrels, and the carton is snapped open along its scored lines, and overlap the two bottom flaps. As the carton on the mandrel reaches the top of the wheel, the bottom of the carton is pressed against a hot plate that descends and seals the bottom seam.
- The mandrel reaches the top of the wheel, the bottom of the carton is pressed against a hot plate that descends and seals the bottom seam. As the wheel continues to rotate, the bottom-sealed carton moves down, and is pulled by suction off the forming mandrel and set down on a conveyor belt.
Diagram 1. The manufacturing process of milk cartons

**Filling and top-sealing**

- The conveyor belt moves the carton to the filling area. Milk from the dairy's storage area descends by pipes to the filling machine. A pre-measured amount of milk fills a chamber above the carton. Then the milk is released through a spout into the carton. The filled carton passes along on the conveyor belt to the top-sealing machine. The top-sealing machine lowers onto the carton and pinches the top together along pre-scored lines. The shape of the conventional milk carton is called gable-topped. The top-sealer forms the gable, and heats and presses the top seam together. As in all the other seams, the polyethylene bonds to itself, and no additional glue is needed.
2.3 Recycling beverage cartons

2.3.1 Collection and sorting

The collection and sorting operations are an important part in the recycling system of cartons. There is a tendency to establish collection by legislation as a way of solving the Municipal Solid Waste problem. According to a World Bank book (Solid Waste Landfills in Middle-and Lower-Income Countries”, 1999), 76% of all solid waste collected in the developing countries is disposed of in inadequate places (open dumps), 13% in managed landfills, 10% in waste landfills, and only 1% is treated (composting, recycling and incineration).

The main collection schemes for Tetra Pak cartons are “Drop Off” system with other light packaging or collection together with the paper stream (the cheapest solution) or “Curb Side Collection” where the “dry material” is collected directly in the households, as curb side collection of cartons and other paper packages.

2.3.2 Washing of polyethylene and aluminum - rejects

The first separation of the fiber from the rejects containing aluminum and polyethylene is done in the hydrapulper discharge. The fibrous material that is suspended in water is removed by pumping. During the pumping the fiber goes through a perforated plate which prevents the passage of the polyethylene and the aluminum. These materials are removed laterally by gravity and go through a washing process where the residual fibers, the polyethylene and aluminum are washed with water (Fig. 1). After washing the recovered fibers return to the process of paper making while the polyethylene and aluminum are pressed in a bale.

The type of separator or plastic washer that has proven efficient is the rotating and non-pressurized cylindrical screen or rotary drum. The recovered fibers that return to the white water system can be recovered by Thickeners or Side Hill Static screens.
2.4 Carton Packaging Recycling Technologies

As part of its corporate environmental commitment, Tetra Pak has been active in assisting paper mills and other interested business to utilize post consumer aseptic carton package as a recyclable resource. Through active technology transfer and encouragement of local process development, three recycling technologies have since been successfully applied in Kenya:

- Hydra-pulping
- Panel board production
- Extrusion molding
2.4.1 Hydra-pulping

Hydra-pulping, or re-pulping in water, is by far the most common process for carton packaging recycling worldwide. At paper mills, carton packages are loaded into the hydra-pulper where hydraulic agitation separates the paper fiber from the carton package (Figure 2). This process normally takes between 30 to 40 minutes in total. Choice of rotor in the hydra-pulper will very much affect the quality of recovered fiber, with mid-high consistency process (6-10% pulp consistency) best suited to achieving a good level of repulping without excessive shear on the paper fiber. It is noted that neither chemical additive nor temperature is necessary for hydra-pulping of aseptic carton packages (Libby, 1962)

The recovered paper pulp upon completion of the repulping process is drained through the perforated plate in the bottom of the hydra-pulper and pumped to the pulp chest.

![Figure 2 Hydra-pulping of Carton Packaging](image1)

![Figure 3 Recycled paper production](image2)

This pulp is then cleaned, screened and refined prior to paper production. Currently, categories of paper produced in Kenya from recycled carton packaging fiber include kraft paper, liner paper and corrugated medium. This fiber is also a choice material being used for production of high-grade shoe mid-soles.
Compared with conventional recovered paper, beverage carton packaging has a relatively higher non-pulp content that can present an operational challenge. Use of a trommel screen (Figure 4) improves pulper emptying efficiency and provides a further washing to the pulper-reject. This procedure improves the overall fiber yield and prepares the polyethylene-aluminum pulper reject for downstream processing by conventional plastic processors.

Figure 4. Trommel screen & re-pulping reject
Aseptic carton package pulper-reject will vary in polyethylene and aluminum (PE-Al) content depending on the mix of different packaging types. This material, delivered to plastic processor in bales (Figure 5), may be put through a final wash to remove trace fiber. The cleaned material is then passed through an extrusion process where the material is heated and extruded into threads.

Duel extrusion may be performed to promote homogenous dispersion of aluminum in the polyethylene, while the extended heat treatment reduces the porosity through evaporation of the moisture content. Extruded threads are submerged in water for cooling before being cut into pellets. These finished PE-Al pellets become the input material for injection and extrusion molding depending on the application of the final products.
(Zuben and Neves, 1999) have conducted a comprehensive study of the properties of this polyethylene and aluminum composite material.
It was shown that whilst presence of aluminum reduces the melting flow relative to virgin polyethylene, the aluminum has no impact during either extrusion or molding applications. With the increased stiffness from aluminum content, however, PE-Al composite performed favorably in selected applications where either high-density polyethylene or polypropylene is normally used. The increased conductivity and x-ray shielding property as a result of its aluminum content makes this composite an interesting material for potential specialized applications. The list of developed products includes sandwiched aluminum plastic panel, drainage pipe, gift items and stationary.

2.4.2 Extrusion Molding Application

This is a patented technology based on the conventional extruded plastic-wood composite manufacturing process. Whole aseptic carton packages are finely shredded and fed into the extrusion machine where the material is heated and extruded through a metal die with a cross-sectional profile of the target product (Figure 7). Post consumer cartons containing as low as 25% plastic as in the case of tetra brick aseptic (TBA) package have successfully replaced plastic and saw dust used in conventional plastic-wood production with satisfactory results in selected applications. Calcium carbonate and/or polypropylene may be added to increase the hardness of the composite material.

Figure 8. Extrusion of floor panels
Currently there is one beverage carton package extrusion facility located in Industrial Area, Nairobi. This processor produces panels and tubular parts with final applications as floor panels, outdoor furniture and rubbish bins (Figures 9 and 10). The 100% post-consumer carton recycled rubbish bins have received favorable reviews by municipal governments as a good example of close-loop recycling. The uncommon constituent of this composite material falling outside of the conventional scrap dealer’s list also offers an added advantage against theft.

**2.4.3 Panel Board Production**

Starting with shredded carton packages, the panel boards are formed under pressure and temperature around 180°C where the polyethylene in the shredded material is melted and are bound together.

Processing time typically varies from 10 to 20 minutes depending on moisture content of the shredded material. Formed panels are either air cooled or put through a cold press. Board thickness typically ranges from 4 to 15 mm, although thicker board can also be made to
Application includes a veneer board substitute in furniture production and construction. The waterproof and flexible characteristics make this board suitable for applications in humid conditions where microbiological activity could otherwise present an issue (e.g. in the case of shipment pallets). (Cerqueira, 2003) described a novel application in Brazil where corrugated press is used to make roofing sheets. This is also done in Kenya today by Ecotech Ltd. In the case of roofing sheets, polyethylene-aluminum pulper reject instead of shredded whole carton is used for better performance in flexion and water resistance.

Indeed. (Figures 11).

Figure 11. Tool shed made from panel boards
CHAPTER THREE

3.0 RESEARCH DESIGN AND METHODOLOGY

3.1 Design of the study

The aim of the research was to establish various ways in which tetrapak packages can be recycled with emphasis on product design to reduce environmental pollution due to poorly disposed packages. The researcher used descriptive research method for the research since this method is used for gathering prevailing conditions.

Two types of data were used; the primary and the secondary data. The primary data was derived from the answers respondents gave during interviews with the researcher. The secondary data on the other hand, was derived from the findings stated in published documents and literatures related to the research problem.

The researcher took the approach of employing both qualitative and quantitative approaches. The quantitative approach focused on obtaining numerical findings and was be used with the observation method. The interview on the other hand made up the qualitative approach of the study as this focused on personal accounts, observations, and description and individual insights of the interviewees. This research employed the combined approach so as to overcome the limitations of both approaches.

3.2 Population and study sample

The researcher collected pertinent information on various ways to recycle aseptic cartons from the general public who use the packages on a daily basis. In addition to the public, the stakeholders involved in the collection and recycling of the aseptic cartons were also interviewed. The respondents included the collectors, the people who sought the cartons and the artisans responsible for the look and feel of the finished recycled products.
3.3 Sample Design and Procedures

In order to limit the selection among the stakeholders, involved in the research, the researcher used some inclusion criteria. These criteria was useful in achieving more generalizable findings from the respondents and helped in limiting the size of the population as well as ensuring that selected participants were knowledgeable on the research topic.

All of the participants were selected through random population sampling. This sampling method is conducted where each member of a population has an equal opportunity to become part of the sample. (Yates, D. S. and David S. M., 2008). In order to conduct this sampling strategy, the researcher will defined the population first, listed down all the members of the population and then selected members to make the sample. For this procedure, the lottery sampling or the fish bowl technique was employed. This method involved the selection of the sample at random from the sampling frame through the use of random number tables. Numbers were assigned for each participant in the master list. These numbers were written on pieces of paper and drawn from a box; the process was be repeated until the sample size was reached.

3.4 Data collection methods and procedures

For this research, the following research instruments were used to collect data on waste recycling and reuse process.

- Guided interviews

These are formal meetings conducted by a reporter or researcher with the aim of obtaining facts or useful information from the respondent. The questions asked varied from one interview to another as some questions were omitted depending on the circumstances of the interviewee at hand such as the amount of time accorded. Consequently, this obliged the researcher to use a structured list of questions best
suited to the interviewees ‘position or role i.e. staff in a relevant organization, level of education and background. This specialization has generally facilitated the process.

- **Observation**

  This involved keenly watching what are being done then taking notes to be analyzed later. The researcher employed this technique at Ecotech recycling plant and by watching relevant documentaries on recycling of beverage cartons.

- **Questionnaires**

  These are research instruments consisting of a series of questions and other prompts for the purpose of gathering information from respondents. The researcher first sampled various informative targets i.e. Product designers, beverage consumers and correspondents from the recycling industry. The list of relevant questions composed thereafter aimed at finding out what the awareness level of the public is on beverage carton waste. The researcher then used them to augment the other data collecting methods as they are cheap and do not require verbal effort from the questionnaire.

- **Publications**

  These are printed works that can be found in public and private libraries, book and magazine vendors as well as in residential places. The researcher explored all these sources to get the relevant information. They range from everyday newspapers, to journals, periodicals and magazines.

- **Internet**

  The internet is a worldwide system of computer networks in which users on any
computer can obtain information. It is characterized by search engines that one uses to narrow down their search for information which is availed in the form of pages. The pages comprise of articles, essays, videos and various books that have been of great help to the researcher especially in developing the literature review section of the study.

By using these data, the results of the research were compared to the outcome of the interview. The evaluation factors were developed in terms of developing an opportunity for re-use of recycled tetrapak packages in product design.

3.5 Data analysis methods

Yin (2003) maintains that data analysis consists of "examining, categorizing, tabulating, testing, or otherwise recombining both quantitative and qualitative evidence to address the initial propositions of a study". The researcher presented the analysed data in different forms to show his findings. The techniques used include the presentation of photographs, tabulation of findings and presentation of analysis of information from interviews and questionnaire

3.6 Limitations

1. Time constraints

The time allocated for actual field research was little, forcing the researcher to eliminate a few potential interviewees who might have offered useful information. This could be due to lack of adequate consideration of all factors influencing the research process like different education levels and as experienced by the researcher, the hectic schedule of the interviewees.
2. **Financial constraints**

Due to a limited budget, the researcher could not visit all the relevant areas. Some of the locations were quite far from the central business district and required the use of motorbike or taxis to reach hence incurring huge travel costs. Since some relevant persons were not available for a face to face meeting the researcher had to make numerous phone calls that were quite expensive.

3. **Weather**

Due to the unpredictable weather conditions during the period in which the research was being carried out, it would rain sometimes rendering some areas inaccessible and when it was sunny, the sun was scorching hot causing fatigue and discomfort to both the researcher and the respondents.
CHAPTER FOUR

4.0 ANALYSIS OF FINDINGS

The research takes the approach of employing both qualitative and quantitative approaches of data analysis.

4.1 Qualitative analysis approach

The interview made up the qualitative approach of this project focusing on personal accounts, observations, and description and individual insights of the interviewees. Other methods of data analysis include the use of flowing charts which represent the cycled observed such as the recycling process, which shows the processes that waste beverage cartons have to go through for recycling to be considered complete.

4.2 Quantitative analysis approach

The quantitative approach will focus on obtaining numerical findings and will be presented by use of pie charts, line graphs and bar graphs to analyze the data. This will be used to highlight comparisons and differences in the collected information.
4.3 Analysis of beverage cartons recycling process

The following flow chart shows the recycling process that beverage cartons go through as observed by the researcher during the research period.
4.4 Analysis of the solid waste in Nairobi.

The pie chart below shows the percentage of beverage carton waste in Nairobi according to the survey carried out in the JICA 1998 report. From the pie chart it is apparent that beverage cartons constitute a small percentage of solid waste hence the reason why not much attention is paid to it in relation to other solid wastes.

![Solid waste chart]

JICA, 1998
CHAPTER FIVE

RECOMMENDATIONS AND CONCLUSIONS

5.0 Recommendations

5.1 Product Design

Throughout this research the researcher noticed the small scale of beverage carton recycling being carried out in Kenya. People do not seem to appreciate the existing recycled products made out of recycled carton, let alone are they aware that they exist in the market. It is only the international clientele who seem to appreciate the value of recycled products compared to Kenyans. The lack of qualified designers with the latest equipment and software for product design leads to the production of less innovative products.

We live in a world where the life of the environment is slowly being choked out and sustainability is the only way forward. Designers are not only stylistic innovators but also problem solvers (Brower, Mallory, Ohlman, 2005). It is the duty of designers to come up with sustainable products.

According to Edwin Datshefski in the article Looks good, Feels good (Brower, Mallory, Ohlman, 2005), all products are destined to wear out, break or become unfashionable. He says that sustainable products have five design requirements as stated below:

- Cyclic- made from compostable organic materials or from minerals that are continuously recycled in a closed loop.

- Solar-the product in manufacture and use should only consume reusable energy that is cyclic and safe.

- Safe- all releases during manufacture and use, to air, water and land provide food for other systems.
- Efficient- the product in manufacture and use requires 90% fewer materials and 90% less energy and water than products providing the equivalent utility did in 1990.
- Socially responsible- the manufacture and use of sustainable products should support basic human rights and natural justice.

In light of this, it appears that the recycling of beverage carton is highly recommended. The researcher will incorporate recycled beverage carton into his final practical project to realise products in industrial design.

The researcher will also look into developing alternatives to the already existing products made from recycled beverage cartons like cardboard boxes, stationary and the likes.

To further explore the options and possibilities of design, the researcher will incorporate various disciplines of product design such as leatherwork, ceramics, jewellery and sculpture to come up with products incorporated from a mixture of recycled cartons and the aforementioned.

5.2 Conclusion

With Kenya’s continual growth in paper production capacity and the corresponding rise in demand for recovered fiber, post consumer beverage carton package is well positioned to become a supplementary source of high quality paper fibers. As the demand for recyclable resource continues to rise, it is foreseeable that a comprehensive municipal waste collection system would evolve overtime to address this need. Experience in other parts of the world has shown it is possible to implement a low cost curbside collection system with government policy and industry support. The result is improved recovery rate and recovered material quality with positive contributions to enhanced environmental management and quality of life.
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APPENDICES

Appendix I: Questionnaire

The researcher is a final year undergraduate student at The School of Arts and Design, University of Nairobi, seeking to study “Opportunities for re-use of recycled beverage cartons in Kenya through product design”. Kindly assist by filling in the questionnaire. The report will strictly be for scholarly purposes only.

1. When was Ecotech started?
   _______________________________________________________________
   _______________________________________________________________
   _______________________________________________________________

2. What are the main aims/objectives of the company?
   _______________________________________________________________
   _______________________________________________________________
   _______________________________________________________________
   _______________________________________________________________

3. Kindly state the amount of waste aseptic cartons recycled annually?
   _______________________________________________________________
   _______________________________________________________________
4. Do you charge any fees for the collection? ________________________
   If so, how do you determine the charges?
   ________________________________________________________________
   ________________________________________________________________
   ________________________________________________________________

5. Please explain in detail the steps followed during the recycling process?
   ________________________________________________________________
   ________________________________________________________________
   ________________________________________________________________
   ________________________________________________________________
   ________________________________________________________________
   ________________________________________________________________

6. Have any designers/artisans approached you to propose a working partnership i.e. they sketch the designs and you make the actual products from the recycled resources?
   ________________________________________________________________

   a) If so, kindly name them?
   ________________________________________________________________
   ________________________________________________________________
   ________________________________________________________________
b) If not, do you have any plans to employ the designers/ artisans in such a programme?

________________________________________________________________________

________________________________________________________________________

7. What affiliate organisations do you work with?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
Appendix II: Questionnaire

The following questionnaire was given to randomly selected people within Nairobi to find out how much they know about aseptic cartons and the recycling programme.

1. Age ______________________

2. Gender
☐ Male
☐ Female

3. Occupation ______________________

4. Have you ever used aseptic cartons? ☐ Yes ☐ No

5. Where do you take the package once you finish using it?
_________________________________________________________________
_________________________________________________________________

6. Do you know of Ecoteck Limited? ☐ Yes ☐ No
7. Are you aware that aseptic cartons can be recycled into different products locally?
☐ Yes  ☐ No

If yes, what products do you know that have been recycled from the cartons?
__________________________________________________________________
__________________________________________________________________
__________________________________________________________________
__________________________________________________________________

8. Would you buy products like chairs, tables for instance made from recycled aseptic cartons? ☐ Yes  ☐ No

If no, please state your reasons_____________________________________________________
__________________________________________________________________
__________________________________________________________________