Source Waste Reduction: A Case Study on Waste Minimization at Beverage Services Kenya Limited (BSK)

Richard Karori Kinuthia

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other university.

Signature: .... Date: ....

Richard Karori Kinuthia

This thesis has been submitted for examination with our approval as university supervisors.

1. Signature: .... Date: ....

Dr. Erastus Gatebe

JKUAT, Kenya

2. **Dr. Joyce Njenga (deceased)**

JKUAT, Kenya

DEDICATION

This research work is dedicated to my father Evans, my mothers Elizabeth & Mary;

My dear wife Josephine,

To my children; Elizabeth and Gladys

To my brothers Abraham, Ezekiel, John, James & Francis

To my sisters Joyce, Mercy, Sarah, Eunice

To my cousins; Ann & Richard and to all my friends who inspired me to be what I am.

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LIST OF ABBREVIATIONS

BM	Blow molder
BSK	Beverage Services Kenya Limited
CIP	Clean In place
EMCA	Environmental Management and Coordination Act
EPA	Environment Protection Agency
JKUAT	Jomo Kenyatta University of Agriculture and Technology
NCP	None conforming products
NEMA	National Environment Management Authority
OE	Operational Excellence
ORP	Ozone recording Point
P.E.T	Poly ethylene terephthalate
RO	Reverse osmosis
SOE	State of the Environment
SW	Solid Waste
SWR	Solid Waste Reduction
TCCC	The Coca-Cola Company
WOMAD	World of Music and dance
WRW	Waste reduction Week
WUR	Water Use Ratio

ABSTRACT

The extraordinary growth of waste globally is an indicator that creating waste, rather than reducing it is more popular. The amount of money spent in disposing of the waste generated, dwarfs the amount spent to reduce it. The reduction of waste generated at the source can be a solution to the current crisis facing most local municipalities and the country at large. Reduction of waste at the source provides avenues and management practices that ensure waste is minimized. This project has studied waste (solid and water) generated at Beverage Services Kenya Limited (BSK), a plant involved in the production of carbonated and non-carbonated products in polyethylene terephthalate (PET) and tetra package containers. To realize this goal, the entire process was divided into distinct units of operation based on the different processes in which the raw material inputs and the process outputs were evaluated to yield a material balance. The material balance indicated the efficiency of the entire process that involved handling and conversion of the raw materials to finished products. Synthesis of the material balance indicated processes with high inefficiencies resulting in high waste generation. Through a waste audit in the specific processes, corrective measures were devised to address the inefficiencies in six out of the fifteen process inputs identified. The implementation of the corrective measures in the six selected inputs resulted in a reduction of waste in the different processes. The preforms had a +0.6% improvement in yields equivalent to a annual savings of nine hundred thousand Kenya shillings. Sugar had a +0.25% yield improvement equivalent to one hundred thousand Kenya shillings savings. Strategic ingredients had a savings of half a million Kenya shillings equivalent to a +3.7% yield

improvement. Water had a 3.8 million liters savings equivalent to slightly over half a million Kenya shillings savings. Carbon dioxide had a +14.1% yield improvement equivalent to over five hundred thousand Kenya shillings savings. The packs had a +5.5% yields improvement equivalent to five million Kenya shillings savings. The result of the entire project was tabulated and analyzed using statistical process control (SPC) charts. At the end of the project, the waste treated outside the plant reduced from ten tonnes in January 2009 to three tonnes in the month of October and November 2009 translating into a 70% waste reduction. The project thus demonstrated that it is possible to reduce waste at the source in a small scale approach such as this case study done at BSK, hence can be extended to cover large scale options like municipalities and the country at large. The project at the end demonstrated the environmental and economic beneficial that can be realized.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Globally, from the historical point of view, the amount of waste generated by the human population was insignificant due to a low population density and little exploitation of natural resources. The common waste generated was biodegradable with minimal environmental impact. Wood was mainly used for most of the application (Kenneth, 2003).

The advent of the industrial revolution in the 18th century made waste management to become a critical issue. This was due to the increase in population and massive rural urban migration. There was consequently an increase in industrial and domestic wastes posing threats to human health and the environment (Nebojša *et al*., 2009). Currently, the two factors still play a key role in the generation of waste. Waste generated in the urban areas is more, compared to the rural areas which have insignificant volumes of waste.

Waste management dates back to 500 BC in Athens, Greece (Kenneth, 2003). Athens was the first city in the western world that had an organized municipal dump where regulations required waste to be dumped at least a mile from the city limits. In the 14th century the English parliament barred waste disposal into the public water ways and ditches (Kenneth, 2003). In the 18th century, recycling of waste was going on in Ritten house mill Philadelphia, where paper was made from recycled fiber originating from waste paper and rags **(**Herbert, 1993). In the 19th century, increase in population and industrialization had a proportional increase in waste generated with some consequences, for example in Great Britain, the population started to suffer from mysterious diseases, which led to the formation of an inquiry team into the sanitary condition of the laboring population. In its report, the Edwin Chadwick's report, linked disease to filthy environmental conditions, and at this point the age of sanitation began **(**Galley, 1977). One of the recommendations in the report was the introduction of the first functional systematic incinerators in 1874 in Nottingham, England. Other countries like the United States, preferred to have waste reduction plants in 1896 for compressing organic wastes (Kenneth, 1996).

Globally, in the beginning of the 20^{th} century, waste was a great problem facing many local authorities and more activities were being done to contain the situation. For example the number of incinerators increased significantly, federal solid waste management laws were being enacted, resource recovery Acts, and establishment of environmental protection agencies to contain the situation (Diana and Emmanuelle, 2008).

As all this took place in Europe, United States of America and other parts of the world, the African continent and parts of South America, Indian and Asian continent were left behind. In the African continent, countries like South Africa had their first institute on waste management in 1976 (The Institute of Waste Management SA, 2004). The catalyst for the formation of this body was the concern these individuals felt for the lack of national attention to Solid Waste Management, the inability of both private and public bodies to work together on the problems of waste and the dearth of either academic or technical training for anyone interested in fields relating to Waste Management.

The Egyptian Government on the other hand, has undertaken waste management keenly from year 2000 by establishing key pillars for sustainable environment (Marwa *et al*., 2005). Some of these key pillars include the legal and policy environment strategies, institutional framework, proper financial arrangement that include a 2 % levy on the rental value of housing units, waste management fee collection through electricity bills and the private sector involvement. The Egyptian Environmental Law regulates the disposal of wastes, but it does not include any clauses that suggest the reduction of waste at the source. This is a short coming in most regulations which tend to deal with end of pipe treatment of waste, a process that deals with the management of the already generated waste. The end of pipe treatment technology and disposal practices not only carry high operating costs, but they also invite future and long term liabilities. **(**Lawrence *et al.*, 2006). These technologies and practices only help to control emissions and wastes to within legal limit of the day, and although the limits protect the public and the environment based on the current understanding of risks, they incrementally add to the stock pile of waste materials. Since these wastes continue to persist long after disposal, the generator is always exposed to both short and long term high risks from the wastes' negative impacts. The only true way to eliminate these liabilities is to eliminate or reduce the waste and pollution in the first place that is, at the source (Nicholas, 2005).

The Kenyan Government on the other hand, has been described to advocate for proper environmental management (Deborah, 2009). This has been through various

Government policy statements, directive pronouncement, sessional papers and Development plans. However, there was no strategic approach for integrating environmental concerns into the development planning process, until the adoption of the National Environment action Plan (NEAP) in 1994 and the consequent sessional paper No. 6 of 1999 on environment and development (Deborah, 2009). In the same year, the National Environmental Management Authority (NEMA) was established under the Environmental Management and Coordination Act (EMCA) No. 8 (1999), the principal instrument of Government in the implementation of all the policies relating to the environment.

The establishment of the above key legislature by the Kenyan parliament was an acknowledgement of the key role played by the environment in shaping the economy. In addition, the Government established a Ministry that looks into Environmental issues in the country. The ministry works together with NEMA, and on the overall they generate a report on the State of the Environment (SOE) for Kenya. The latest report available was done in 2003 by the Ministry of Environment, Natural Resources and Wildlife. In the report, the country is described as an emerging economy, currently with a vision 2030 to help in laying out strategies and policies for growth by the year 2030 (Ministry of environment, Natural resources and Wildlife State of the Environment for Kenya, 2003). The country will have rural urban migration of its citizens, more industries coming up, more transformation of raw materials into high value goods and increased use of agrochemicals to improve agricultural productivity. These development activities are accompanied by generation of various types of wastes that find their way to the environment. The waste can either be in the urban areas also referred to as municipal waste or in the rural areas. The rural waste is easy to deal with at the homestead level. Municipal waste poses the greatest challenge due to high population influx to the urban areas and industrialization continues to increase in these zones. On estimate, the SOE 2003 report indicates that approximately 21% of these wastes emanate from industrial areas and 61% from residential areas (Ministry of environment, Natural resources and Wildlife State of the Environment for Kenya, 2003).

In year 2003, only 32 local authorities out of 174 had some form of waste collection and disposal infrastructure (Ministry of environment, Natural resources and Wildlife State of the Environment for Kenya, 2003). At the moment, this statistics has not changed much and the few local authorities with infrastructures on waste management do not comply with the minimum legal requirements. (United Nation Environmental Programme, 2005). The country is therefore, faced with a waste management problem at hand that requires each and every person's involvement. The Government must ensure that the laid down legislations and local authority by-laws are implemented and adhered to. This includes the 'polluter pays principle', a clause in EMCA 1999 that can ensure that any person polluting the environment pays for the pollution and rehabilitates the affected area to a better state. The 'polluter pays principle', makes each individual or organization responsible to care for the environment. BSK, being part of the giant Coca-Cola Company is not exempted from this principle, and thus has a responsibility to conduct its activities in a manner that does not impact negatively on the environment. The company as per the state of the environment for Kenya 2003 contributes a certain percentage to the 21% waste generated from industries from its operations, especially plastics in PET form, paper and waste water.

1.2 Beverage Services Kenya Limited Profile

Beverage Services Kenya (BSK) limited is a subsidiary of The Coca-Cola Company (TCCC) licensed to bottle carbonated and non-carbonated soft drinks in polyethylene tere-phthalate (P.E.T) and tetra package. The package is convenient, attractive and can be product specific in designs. The plant started its operations in October 2002 with 100% shareholding of TCCC. The ownership was further split among the local bottlers to make the company a local franchise wholly incorporated in Kenya funded 100% through share subscriptions. Contribution by the different shareholders is given in Table 1. The major shareholder is TCCC with 38% shares, followed by the South African Bottlers Company (SABCO) the proprietors of Nairobi Bottlers Limited with 30% shares, the SHAH's family, owners of the Equator Bottlers Limited (EBL) in Kisumu and Coastal Bottler Limited (CBL) in Mombasa with 14% shares, Mount Kenya Bottlers Limited (MKBL) in Nyeri and the Rift Valley Bottlers Limited (RVBL) in Eldoret with almost an equal share of about 6.0% and Kisii Bottlers Limited (KBL) in Kisii with 5.4% shares.

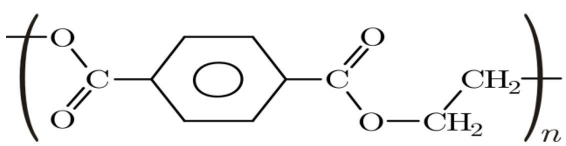
Table 1 Contribution by the different bottlers to the share capital

Company	Contribution in Share Capital
The Coca-Cola Company (TCCC)	38.1%
South African Bottler Company (SABCO)	29.9%
SHAH'S Family	14.1%
Mt Kenya Bottlers Limited (MKBL)	6.4%
Rift Valley Bottlers Limited (RVBL)	6.2%
Kisii Bottlers Limited (KBL)	5.4%
Total	100%

BSK is a plant of its kind within the Coca- Cola bottling system in the African region as the packaging of its products is in the P.E.T and Tetra package. It acts as a pilot project plant to monitor the sales performance of new products being introduced by the Coca-Cola Company within the Kenyan region in terms of volume growth before the final commercialization within the bottling system. The sales volume targets have already been realized and surpassed the projected growth of 25 % per annum (Operations report, Beverage Services Kenya Limited, 2008). This increase in volume has a similar proportional increase in the waste generated at the plant level and therefore the need to manage the entire manufacturing process to minimize or eliminate waste generated. In this project, both waste water and solid waste generated in the entire process has been considered with special emphasis on the P.E.T. waste.

1.3 P.E.T definition

P.E.T is poly (ethylene tere-phthalate), commonly abbreviated PET, PETE, or the obsolete PETP or PET-P). The chemical structure of the poly ethylene tere phthalate is shown in scheme 1. It is a thermoplastic polymer resin of the polyester family and is used in synthetic fibers; beverage, food and other liquid containers, thermoforming applications; and engineering resins often in combination with glass fiber carpets. It is also used to manufacture fabric and insulation for winter jackets.



Scheme 1 Chemical structure of polyethylene tere-phthalate where n is the number of repeating units which vary

Plastics come from one of the earth's finite limited resources, crude oil (Kirkwood and Longley, 1995). The Oil refineries produce a naphtha fraction which is one of the two hydrocarbon feedstock that is fed to an ethylene cracker. Another hydrocarbon feedstock is ethane which comes from natural gas. The product from the ethylene plant, ethene (ethylene), propene (propylene), butenes, butadiene, and aromatics, are the basic building blocks that are the starting point for the production of petrochemicals and plastics (Herbert, 1971).

The use of P.E.T has a major environmental impact that if not mitigated can lead to health hazards and environmental degradation. The pollution from plastics affects air, land, and water. Many plastic bottles end up in landfills or get incinerated. Burning plastic, releases toxic chemicals into the air. P.E.T does not biodegrade; rather, it photo degrades, which means that, under sunlight, it just keeps breaking down into smaller pieces (Nurdles). Nurdles can enter the food chain when they are eaten by terrestrial, marine animals and birds. Nurdles also soak up toxins, adding to the poisons consumed by the primary consumers then through the food chain to secondary and tertiary consumers. As P.E.T does not decay fast, its waste occupy precious land space and at the same time creating a hospitable environment for bacteria and other opportunistic vectors, thereby potentially causing a health risk for people who come into contact with them (Harry, 1990). Therefore P.E.T process must be checked to reduce on the waste generated to avert the above issues.

1.4 P.E.T Handling Process

At BSK the P.E.T. handling process follows a number of steps as indicated in Fig. 1. The process starts with receiving of the P.E.T inform of preforms packed in cartons with ten thousand pieces. They are stored in a warehouse from where they are issued to the production department for conversion to bottles at the blow molding machine. The bottles pass through an air conveyor that leads to a rinser unit, which rinses the bottles before the filling process at the filler unit. The filled bottle is then date coded by a laser machine, inspected for the proper fill height, labeled, physically inspected again for defect, tamper seal evidence put, made into a case , palletized and then it is taken to the warehouse as a finished product.

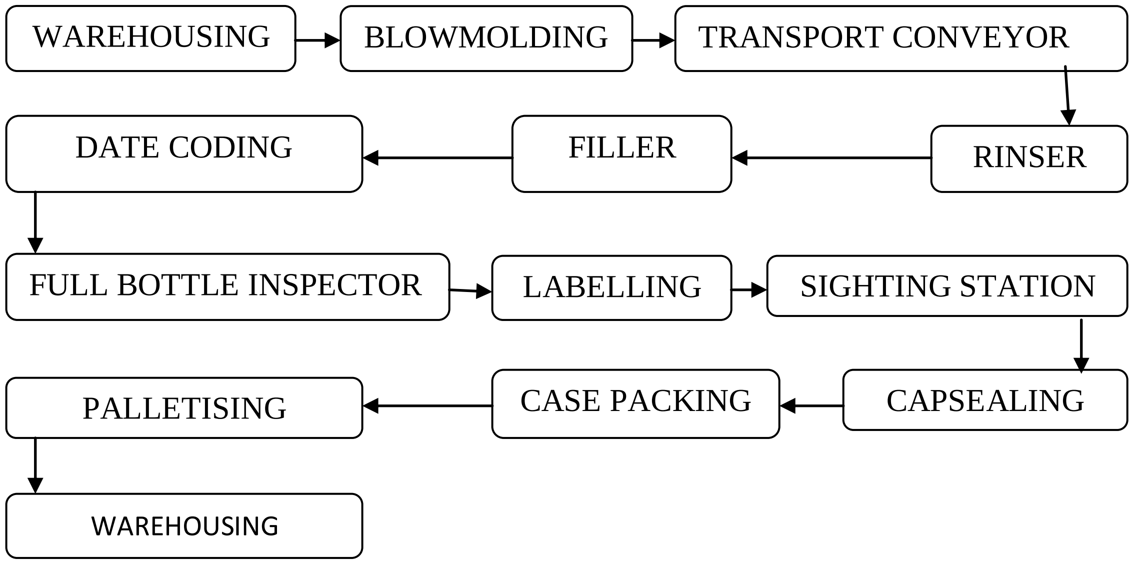


Figure 1 Polyethylene Terephthalate handling process flow chart

Other types of waste generated within the plant have been considered in this project and they include; damaged pallets, cartons, bags, plastic pipes, 20 to 250 litres plastic containers, polythene papers, chip boards, metal drums, old furniture and fixtures, electronic waste, used papers, demolition waste, dust and food waste among others.

1.5 Statement of the Problem

At the moment BSK has not put up proper mechanisms or management practices that prevent or reduce generation of waste at the source. Some processes that require controls include, raw materials processes, waste in production facilities in terms of product volume and weight, increased product durability, reusability and high efficiency in the manufacturing process. Proper legislations to control the use of specific wastes like P.E.T. are also lacking.

1.6 Scope and Site of Study

The project has been carried out at Beverage Services Kenya Limited, a plant located in the Nairobi Industrial Area, Likoni road off Jogoo road, opposite the British American Tobacco and neighboring Taptok limited as indicated in Fig. 2.

Figure 2 BSK site map

The company is in the production of carbonated and non-carbonated beverages under license from the Coca-Cola Company. It was the only company packaging these products in P.E.T. package until December 2008 when the second company Nairobi Bottlers Limited was licensed to do P.E.T. packaging of the same Coca-Cola products. This project, has evaluated the entire waste generated at BSK with special reference to the polyethylene terephthalate waste.

The research findings on reducing waste at the source will be extended to the other bottlers installing P.E.T. packaging lines and tetra package lines within the system.

1.7 Objectives

The main objective of this study was to establish a waste reduction management system at BSK.

Specific Objective included

1. Defining sources, quantities and types of waste being generated in the different processes
2. Collates information on the different processes which included raw materials, products, water usage and wastes generated
3. Highlight process inefficiencies and areas with poor process management.

1.8 Hypothesis

Null Hypothesis

It is not possible to reduce waste at source in a plant

Alternative hypothesis

It is possible to reduce waste at source in a plant

1.9 Rationale and Justification

Between year 2004 and 2008 there was a seven fold increase (4.9 million units to 34 million units) in P.E.T production which was not attained at the same rate over the four year period as summarized in Fig.3, based on the existence of a single line. A second line was installed and commissioned at the beginning of year 2009 resulting to P.E.T production doubling from 34 million units to 76.8 million units, figure 3. The sixteen times growth rate in P.E.T production from year 2002 to year 2009 resulted in a significant increase in the P.E.T waste generated due to process inefficiency in the production process. With the negative environmental impacts highlighted above, it was then critical to control this waste at the production process level which is the source hence reap both environmental and economic benefits.

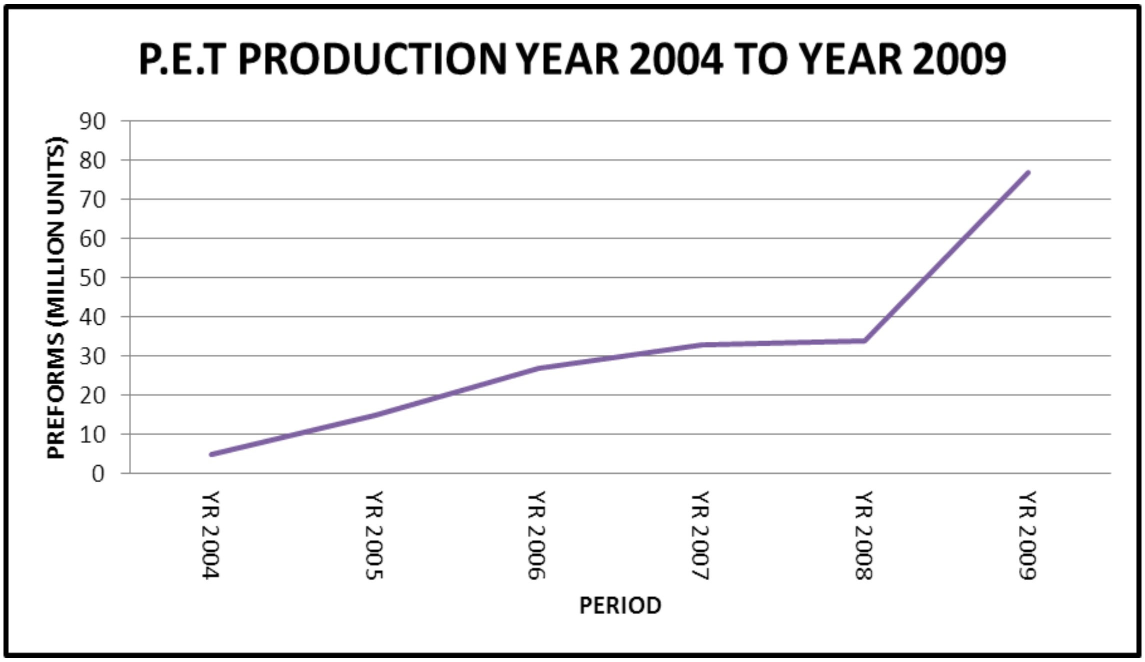


Figure 3 A Six year Trend of P.E.T Production. BSK operations report (2009)

Therefore proper methods to control waste generation at all levels in the production process are required to avert serious environmental and economic impacts.

CHAPTER TWO

2.0 LITERATURE REVIEW

Globally, a lot has been undertaken on waste management but it was not until the 21st century when reduction of waste at the source (waste minimization or reduction) started taking roots in many developed countries. This has not been the case in the developing countries which are still struggling to put up industries and efficient processes. Waste minimization is taking different directions globally ranging from countries concentrating on different types of waste or in totally different fields (Bandyopadhyay, 2006).There is enough literature for instance on reduction of waste at homes and industries (Department of Environmental Protection Harrisburg, PA, 2003) managed by the California Integrated Waste Management Board (CIWMB) and also at the industrial level. In china a lot has been done on waste reduction at home also (Shan S and Chi S, 1996).

NORTH AMERICA

In North America, a country like Canada has a waste reduction week (WRW) every 19th to 25th of October each year. It has been developed and delivered by a coalition of thirteen different recycling councils and sister organizations from across the Country. The Program focuses on the 3Es (Education, Engagement and Empowerment) of the 3Rs; (Reuse, Reduce and Recycle) (Recycling council of Ontonia, 2010). Waste Reduction Week in Canada, aims at informing and engaging Canadians on the environmental and social ramifications of wasteful practices. The program's educational resources and "take action" messaging, empowers all Canadians to adopt more environmentally conscious choices. Waste Reduction Week provides information and ideas on how to reduce waste in many fields; encouraging people to embrace reduction of waste at source as one solution to the many environmental challenges faced globally that include climate change, water pollution and preservation of natural resources. The program includes the distribution of promotional and resource materials, which provide information on the 3Rs emphasizing waste reduction and are also availed in dynamic and user-friendly website, which provides participants with facts and statistics of waste and waste related issues and hands on tools encouraging action on waste reduction.

UNITED KINGDOM

The United Kingdom has the Beacon Council whose mandate is to work with the local authorities on waste reduction (Beacon, 2003). Some of the councils under this group include London Borough of Bexley, Rushcliffe Borough Council, Redcar and Clevel and Borough Council among others. The projects undertaken so far include encouraging the use of real nappies with activities like availing information boards and leaflets at all road shows, free or reduced-priced real nappies and the production and delivery of a county-wide leaflet introducing residents to the scheme. Another project involves tackling junk mail that includes billions of items of unaddressed mail that ends up in landfill sites each year. Activities involved include a public awareness campaign, which has included anti junk letter box stickers and a voluntary code of practice for local businesses such as pizza and curry restaurants. The council is also encouraging composting of waste, waste recycling and reuse among other activities.

UNITED STATES OF AMERICA

United States of America on the other hand, under Environmental Protection Agency (EPA) has Waste Wise Group, launched in 1994 with more than 2000 partners who include businesses, local governments, and non-profit organizations of all sizes and from all industry sectors (Environmental Protection Agency, 2011). The partners range from small local governments and nonprofit organizations to large, multinational corporations. They have the Waste Wise Endorser Program (WWEP) engaging state and local government agencies, trade associations, nonprofit organizations, and businesses to help educate their members and constituents about the benefits of reducing solid waste. Some of the benefits to the members include, reduced purchasing and waste disposal costs, partners pooling resources together to control waste generation among other benefits (Environmental Protection Agency, 2010A). The target waste includes reduction of municipal solid waste and selected industrial wastes. Municipal solid waste includes materials that could end up in an organization's (or its customers') trash, such as, corrugated containers, office paper, yard trimmings, packaging and wood pallets. Industrial waste include, hazardous batteries, coal combustion products, foundry sand, hazardous sludge’s, oil filters, non-hazardous ink and porcelain. The EPA recognizes that between 1960 and 2007 the amount of waste each person created almost doubled from 2.7 to 4.6 pounds per day (Environmental Protection Agency, 2010A). The most effective way to stop this trend is by preventing waste in the first place. EPA identify that the practice involves designing, manufacturing, purchasing, or using materials (such as products and packaging) in ways that reduce the amount or toxicity of trash created.

Reusing items also stops waste generation at the source because it delays or avoids that item's entry in the waste collection and disposal system. The achievements highlighted include a reduction of waste at the source of more than 55 million tons of municipal solid waste (MSW) in the United States in the year 2000, the latest year for which these figures are available in which the containers and packaging represented approximately 28% of the materials reduced at the source. In addition, non-durable goods (e.g., newspapers, clothing) were at 17%, durable goods (e.g., appliances, furniture, tires) at 10%, and other MSW (e.g., yard trimmings, food scraps) at 45%. There was also an increase in reuse centers to more than 6000 among other benefits (Environmental Protection Agency, 1997).

Globally this has helped to save natural resources, reduce costs and create awareness enabling communities to institute "pay-as-you-throw" programs where citizens pay for each can or bag of trash they set out for disposal rather than through the tax base or a flat fee (Environmental Protection Agency, 1998) .

NEW ZEALAND

New Zealand has the world of music, arts and dance (WOMAD) group with the same concept of waste minimization but with a different name. The concept zero waste is used to encourage everyone to strive not to generate waste (Taranaki Regional council, 2009). The group was founded in 1980 by Peter Gabriel, Thomas Brooman, and Bob Hooton on the basis that many people would share their enthusiasm for music from other cultures, if only they had the opportunity to listen to some of the global sounds. The concept evolved from an idea Gabriel had at a concert involving an African group. This then developed into a much larger event incorporating music from all over the world. The group has developed and adopted zero waste as a powerful concept that challenges the old ways of thinking and inspires new attitudes and behavior towards conserving the earth's limited resources. It is a multi-faceted approach integrating four R's of waste minimization; Reduce, Re-use, Recycle and Re-think (Taranaki Regional council, 2009). WOMAD is committed to ensuring that the event isn't only a spectacular celebration of international culture, sight and sound, but also becomes a shining example of how to minimize waste at large events. The Zero Waste strategy actively encourages everyone involved in the festival to contribute to the Zero Waste goal, from the artists performing to the public attending the festive. They have annual events and 2009 saw the new addition to the Festival of the Sustainable Village, showcasing sustainable practices, merchandise and concepts, featuring small and large companies and organizations that implement methods or offer products supporting sustainable practices. The festival also saw the introduction of water bottles, which are refillable with chilled water. This initiative will reduce the number of water bottles going into landfills.

WOMAD New Zealand has been developing a stronger focus on environmental issues since 2006. The Zero Waste Strategy has been successful and has developed a benchmark for other events to establish zero waste principles to work on. Some of its strategies include reduction of the amount of rubbish sent to landfill; fewer landfills mean more space and better air and water quality. Zero waste is hence all about caring for the environment now, so that future generations can also enjoy our beautiful world.

They are encouraging the use of recyclable, reusable, biodegradable or compostable containers. Currently the group performs in many countries across the globe.

AFRICA – SOUTH AFRICA

In Africa, only South Africa (SA) had this concept of reducing waste at the source as early as year 2000. In Howard College campus of KwaZulu-Natal University, they established a Pollution Research Group led by Susan Barclay to explore on the waste minimization options (Susan and Chris, 2001). They have done several projects that include, determining the feasibility of establishing waste minimization clubs in South Africa as a route to promoting cleaner production in industries, waste minimization guide for the textile industries, industrial waste minimization in South Africa (Susan and Chris, 2000C)**,** water and effluent management in the South African textile industries (Susan and Chris, 2000B) and the establishment of a methodology for managing waste minimization clubs in South Africa. Waste minimization encompassing, activities that any company, organizations or group of individuals can implement to identify sources of waste and work towards reducing it, or eliminating these waste. (Oelofse S. and Godfrey L,2008). To achieve the above in South Africa, several companies came together to form an association with a common goal to exchange information and ideas on waste minimization. In this way, they encouraged one another to reduce waste at source, resulting in financial benefits to themselves and a reduction in their emissions to water, land and air. As an association, these companies benefit from one another’s experiences and receive assistance from outside consultants at a reduced cost. The concept has been successful in Europe and the United Kingdom and it was felt that this approach could be applicable in South Africa (Susan and Chris, 2001).

The Pollution Research Group undertook a three year research project, sponsored by the South African Water Research Commission (SAWRC), to determine the feasibility of establishing waste minimization clubs in South Africa to promote sustainable industrial development. Two pilot clubs were formed in kwaZulu Natal, one in the metal finishing sector in the Durban region, and the second, a cross-sectoral club in the Hammarsdale area (Susan and Chris, 2001). This project ended in December 2000, and the results from this study have been used to prepare guidelines for the establishment of future waste minimization clubs in South Africa. The result of the study indicated that approximately 1,280 Million liters of water was saved by seventeen companies over the three years, leading to a reduction of 1 230 Million liters of effluent discharged to drain (Susan and Chris, 2000 A). On energy a total of 65.7 Giga Watt hour was saved by ten companies over the same period, resulting in a reduction of 45 000 tons of Carbon dioxide emission, 425 tons of Sulphur dioxide and 190 tons of Nitrogen Oxides being emitted to the atmosphere (Susan and Chris, 2000 A). The majority of the savings was achieved through improved housekeeping practices and was transferred to the companies through the association meetings, training and site visits. Training in waste minimization was essential for the success of the project and involved all employees, from management to shop-floor level. In the same project more than 900 people were capacitated through the project and more continue to join the training institute. The waste minimization association concept was growing with more individuals pooling strings together to attain the same benefits as highlighted. The teaming up in this area has shown a lot of success in promoting the concepts of waste minimization to industry with the result indicating companies making financial savings and reducing negative environmental impact. A second water research commission sponsored project has been going on to promote the establishment of further associations in the country through the preparation of a facilitator's manual and training materials.

EGYPT

Egypt on the other hand has waste management policies which are not well outlined like the South African model. The country adopts clean technology as a long-term national objective that requires integration with the present industrial activities (Farida and El-Din, 2007). However, before its promotion within the industrial base, it may be necessary that each sector acts and reduces waste to meet the new regulations.

Some of the challenges faced in the implementation of a source waste reduction project within a country or a company include failure by the members to attend meetings and training sessions which could be due to commitment in work places, lack of commitment from senior management or a lot of responsibilities to the project leader. Lack of progress is also a challenge due to lack of time by the project leader (Susan and Chris, 2000 C). Frequent audits, getting staff to assist, training and visiting other sites doing well on waste minimization helps to overcome this hurdle. An association of industries doing the same business will do well on source waste reduction as they have a lot in common but competition or business rivalry between members can be an obstacle to achieve results for fear of revealing trade secrets, poor attitude within the association can also be an obstacle but results prove otherwise.

Failure by the Government regulatory bodies to ensure the implementation of the current legal requirements especially on waste management is a major obstacle. Other barriers faced by many companies include time, lack of resources in terms of personnel, data, finance, process, politics which include lack of commitment and communication breakdown, culture on the way people think and fear of personnel to make suggestions.

The greatest barriers to waste minimization in many companies are lack of finance, information, technical knowledge, ambiguous legislation and operational constraints (Susan and Chris, 2000 C). Susan continues to say that it is interesting to note that while the industry as a whole did not feel that they were resistant to change, the regulators saw this as the main reason why waste minimization was not being implemented. In addition, lack of time was not considered a barrier; although later it became evident that this was one of the greatest problems facing companies in implementing a waste minimization programme. The main drivers identified by the companies were the savings that could be made, an improved environmental performance and more stringent legislation.

India National Productivity Council (INPC) on the other hand has done a lot on waste minimization with case studies on textile, rice mills, distillery units, paper mills, refined edible oil and dye manufacturing plants (National Productivity Council, 2004,). Barriers experienced include policy barriers, economic barriers, technical barriers, regulatory barriers, cultural barriers and mental block (an inability to remember or think of something you normally can) (Susan and Chris, 2000 B). A lot on productivity improvement and waste reduction through recycling (Dalgobind and Anjani 2010) is also available.

The situation in Kenya is different on the waste management sector, with the exception of Nairobi, there is scanty statistical analysis on waste management. The literature dwells largely on performance description and its causes, household waste generation behavior, and waste characteristics. Waste minimization, reduction or zero waste are new terms in our environmental policies. Major projects being undertaken that revolve around waste management include the Ministry of Environment and Mineral Resources, Nairobi Rivers Rehabilitation and Restoration Programme (2008). The data as summarized in Fig. 4 from the report indicated that about 54% of the total waste is biodegradable organic waste, 14% is recyclable paper, while in the third position is recyclable plastic contributing 10%. Although plastics constitute only 10% of the total waste in Nairobi, it is a major concern because plastics are not biodegradable, on burning plastics dioxins are released that are harmful to human health and tiny bits of the plastic (nurdles) are eaten by animals introducing poisonous chemicals across the food chain among other negative effects. Plastic waste generated can be reduced by managing the entire plastic cycle especially the production processes at the source. The application of the legal framework available can help in defining modes of waste management and the consequence of not managing this waste. (Japan International Co-operation Agency, 2002).

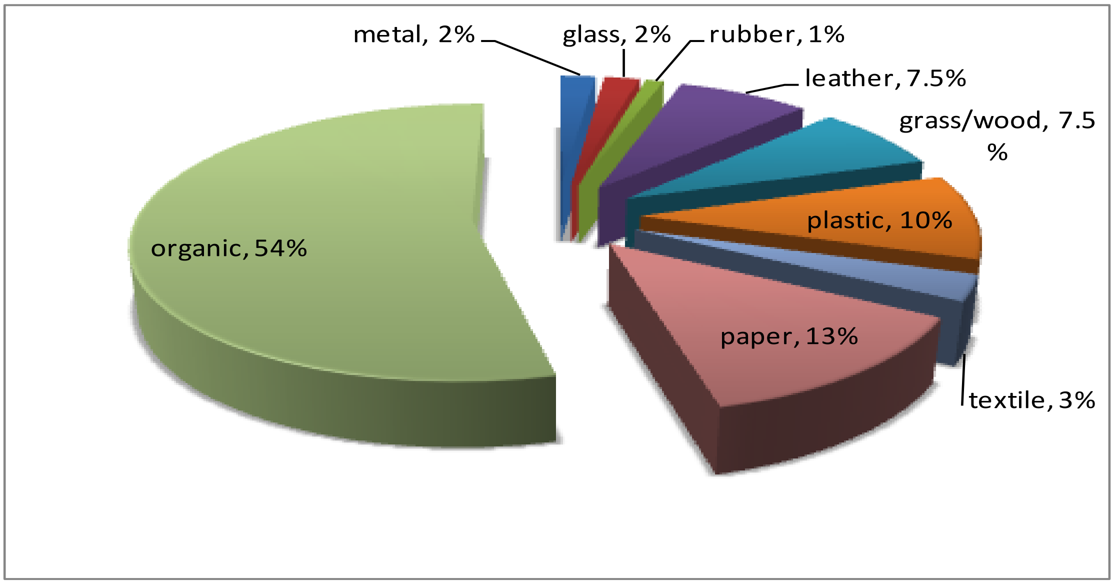


Figure 4 Nairobi city solid wastes contribution (Nairobi rivers rehabilitation and restoration programme, 2008)

The enactment of the Environmental and Coordination Act (1999) in Kenya was to ensure that every person in Kenya has access to a clean and healthy environment and has a duty to safeguard and enhance a clean environment. The above waste generated within Nairobi area is a contribution from many estates and industries like BSK. BSK hence legally has a duty to safeguard and enhance a clean environment as it contributes to the 10% plastic waste, and other wastes generated in Nairobi. The more waste the plant generates in P.E.T. form, the more plastic is introduced into the plastic bank. Therefore it is essential to embrace a waste reduction at the source to cope with the increasing environmental impacts highlighted earlier.

CHAPTER THREE

3.0 MATERIALS AND METHODS

The materials necessary to carry out this project included Sorting containers, transporting bags, sampling bottles, measuring cylinders and Sampling beakers. Equipment's involved included the pH meter, conductivity meter, TDS meter and the Calorimeter for specific residue ions analysis.

The methods of choice to deliver the results had two steps that included

a. Auditing the individual processes to gather data and information necessary to address the objectives of the project. The information and data collected was used to build up the project actions stepwise from phase one to phase three.

b. Data analysis was done using statistical process control charts to indicate the project performance trend.

The two methods highlighted above were executed in a sequence of steps highlighted in in Fig.5 below.

3.1 The Conceptual Framework

PHASE 1: PREASSESSMENT

- STEP 1 Prepared and organized the audit resources
- STEP 2 Divided process into unit operations
- STEP 3 Constructed process flow diagrams linking unit operations

PHASE 2: MATERIAL BALANCE

- STEP 4 Determined inputs
- STEP 5 Determine the water usage
- STEP 6 Measured current levels of waste reuse and recycling
- STEP 7 Accounting for waste water
- STEP 8 Accounted for gaseous emissions
- STEP 9 Quantified products and by products
- STEP 10 Accounting for off-site waste treatment

PHASE 3: SYNTHESIS

- STEP 11 Sorting of waste at BSK
- STEP 12 Developing Long term waste reduction options
- STEP 13 Environmental and economical evaluation of waste reduction

Figure 5 The project implementation steps

3.2 Phase 1: Pre-assessment steps

The pre-assessment phase had three steps that included preparation and organizing the audit resources (that includes obtaining commitment to the programme from senior management and the selection of a project team to assist in data collection), breaking down the process in simpler units of operation to make data collection easy and construction of the different processes flow charts in each of the units. At the end of phase one, the units of operation were defined and individual processes flow charts constructed.

3.2.1 Step 1: Audit Focus and Preparation

The preparation for the audit was carried out by holding meetings with the management to get their commitment as little could be done without their involvement. The project involved undertaking a waste audit with the contribution from all the employees especially in the warehouse and the processing areas. Personnel from each stage of the manufacturing process got involved in the project to have their contribution factored in. They were in a better position to make meaningful contributions towards this project as their understanding of the processes was better and could give better solutions to the waste generation problem in areas of operation.

Laboratory services preparation was also undertaken with the choice to use the existing laboratory equipment's and reagents within the plant and to out-source other services from Aquatech industries limited, a National Environmental Management Authority (NEMA) accredited laboratory. The scope of the audit was defined to cover all the processes, from the receiving of materials in the plant, to the distribution of the finished products from the warehouse, with the aim of reducing all types of waste generated from the individual processes at the source. On reviewing the documents and records, the following were analyzed, the site plan, process flow diagrams, monthly departmental reports on material usage, production outputs and an evaluation of waste disposal manifests.

3.2.2 Step 2: Listing Unit Operations

A unit operation is an area of the process or a piece of equipment where materials are put (input), processing takes place and products are produced (output), possibly in a different form, state or composition. At BSK, the units were taken to be the different processes within the plant. In each process, materials flow from the raw material warehouse to the production areas for processing and finally to the finished products warehouse from where they are shipped out to the market. Most of these units fall under production, but other units like the administration supporting production to deliver goods and services to our esteemed customers were considered. Six units of operation were identified and they included the raw material warehouses, the production process with four lines operating, the finished products warehouse, water treatment section, the wash room's facility and the administration block that includes a staff canteen. With the six operational units defined, it was easy to construct a flow chart for each of the processes.

3.2.3 Step 3: Construction of Flow Diagrams

Flow charts were preferred for the individual processes because of the ease to pick out all issues at every step in the raw material conversion process to finished product. They indicate where a process starts and outline every activity carried out at each step. In this step, five flow charts were constructed as indicated below.

3.2.3.1 The Production Process flow chart

This process involves the receiving of raw materials (the ingredients, primary raw materials – those that come into contact with the product, and the secondary raw materials – only in contact with the primary package) from the system approved suppliers, the inspection of the raw materials and their storage in the raw materials warehouse. After production planning, the raw materials are issued to the production department for processing into finished products. This involves product preparation and package preparation. The product preparation involves the dissolving of sugar in water and adding strategic ingredients for the specific products. The package preparation involves conversion of a preform (P.E.T in a material that has undergone preliminary shaping into a bottle but is not yet in its final form) into a bottle through heating, blown using air into a final bottle then rinsed before filling. The filling stage involves putting product into the bottle adding a drop of nitrogen if the process specifies that, then capping. After securing the product into the package it is labeled, packed into a case using a tray and a shrink wrapper, palletized, stretch wrapped and finally stored in the finished product warehouse awaiting distribution as per Fig.6.

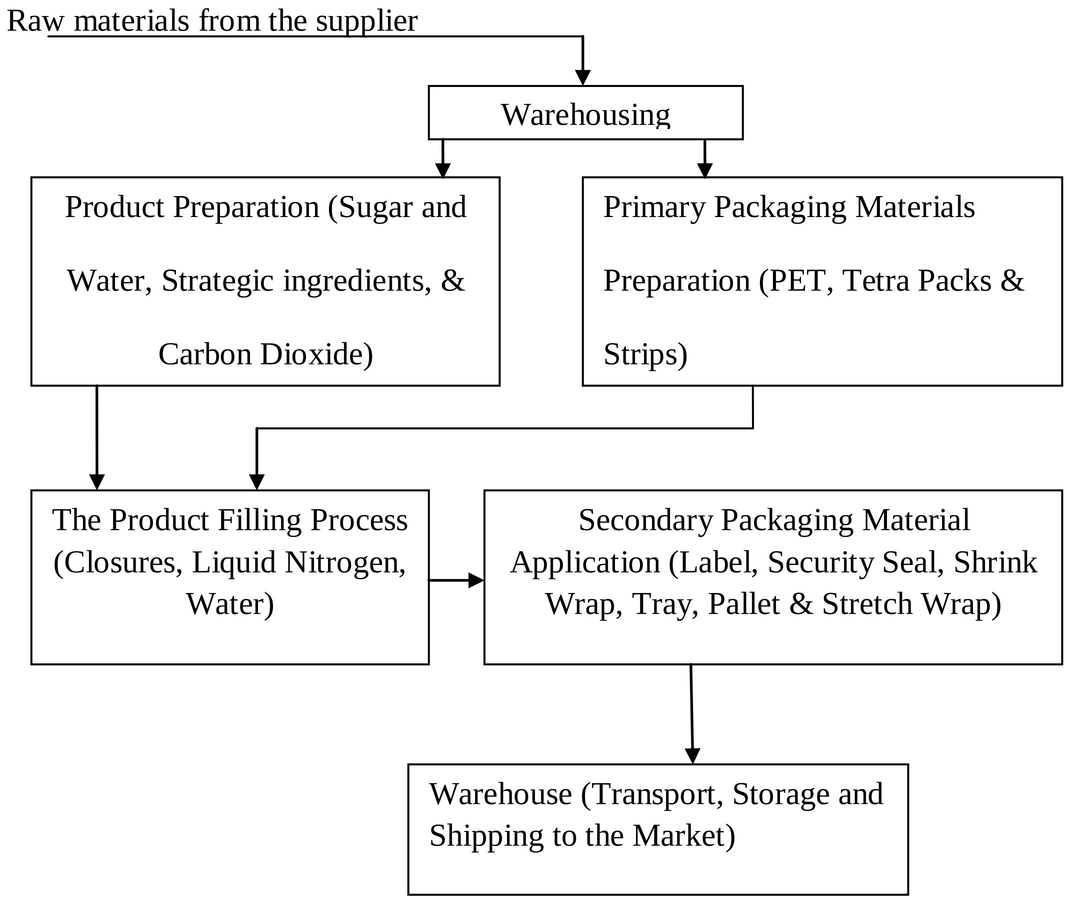


Figure 6 The Production Process flow chart

3.2.3.2 The water supply

The plant has two sources of water, the borehole supply and the municipal supply.

The municipal supply is sourced from the Nairobi Water and Sewerage Company Limited into a 45m^3 reservoir. The water is then fed without treatment to the firefighting water reservoirs, the utilities section and the administration block Fig. 7.

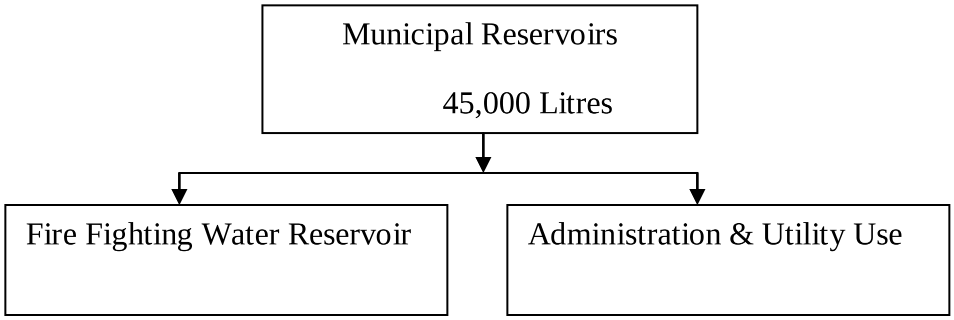


Figure 7 The municipal water flow chart

3.2.3.3 Municipal water flow chart for the utility section

The municipal water from the municipal water reservoir is distributed to support the utilities highlighted in Fig.8. The compressors have cooling towers that use a lot of water. Frequent replenishing and draining of the water is necessary to maintain high cooling efficiencies.

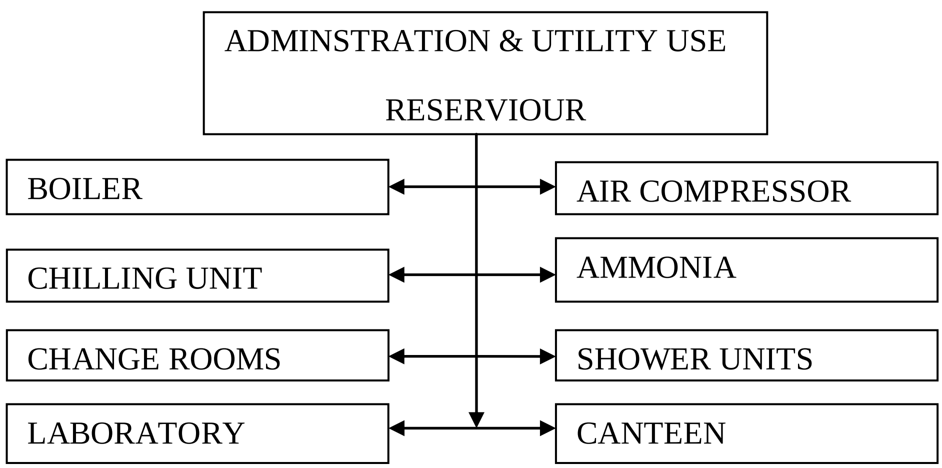


Figure 8 The Municipal water flow chart in the utility section

On the other hand, the borehole water is sourced from a 252m deep well and passed through a series of steps that include a reservoir that has a capacity of $80m^3$. From the reservoir the water is pumped to the water treatment section at a rate of $50m^3$per hour through chlorination (the process of adding the element chlorine to water as a method of water purification through disinfection), flocculation (addition of a chemical to have colloids in water come out of suspension in the form of floc or flakes through the formation of polymer bridges between the particulates) and coagulation(through neutralization of the charges of the particulates and combining them thus grow in size and become easy to filter). The floc formed above is then filtered through the sand filters to a holding tank. In the holding tank contact time between chlorine and microorganisms in water is enhanced. The chlorine in the water can introduce odor and an off taste in products; hence it must be completely removed by the carbon purifier. The chlorine free water then passes through the reverse osmosis system for further purification.

Reverse osmosis (RO) is a filtration method that removes many types of large molecules and ions from solutions by applying pressure to the solution when it is on one side of a selective membrane. The result is that the solute is retained on the pressurized side of the membrane and the pure solvent is allowed to pass to the other side. To be "selective," this membrane should not allow large molecules or ions through the pores (holes), but should allow smaller components of the solution (such as the solvent) to pass freely. The process uses a mechanical device to force a solvent from a region of high solute concentration through a semi permeable membrane to a region of low solute concentration by applying a pressure in excess of the osmotic pressure. In this case the solute is the well water with high mineral concentration that yields a solvent, which is water with low mineral content. At the time of this project the reverse osmosis was recovering 60% of the feed water and 40% was rejected and used as a vehicle to carry away the minerals left on one side of the system to the drain. The recovery rate could be optimized to leave 30% to act as a vehicle for removing the minerals filtered in the system. The water treatment system requires backwashing and a normal chemical cleaning to prevent minerals build up. A summary of the water treatment is indicated in Fig. 9.

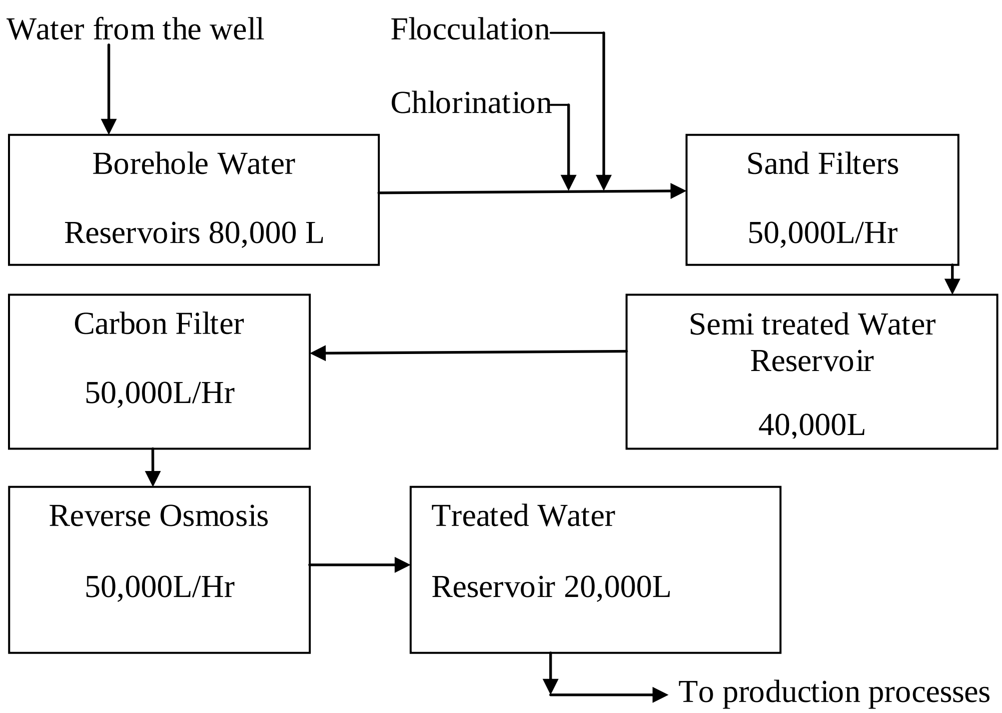


Figure 9 The well water treatment process flow chart

3.2.3.4 Treated water flow chart in the production area from water treatment

The treated water is distributed through stainless steel pipes to all the four lines summarized in Fig 10, then to the product and cleaning solutions preparation areas for all the four lines. The treated water can also be used in the utility section when there is a shortage in municipal water supply.

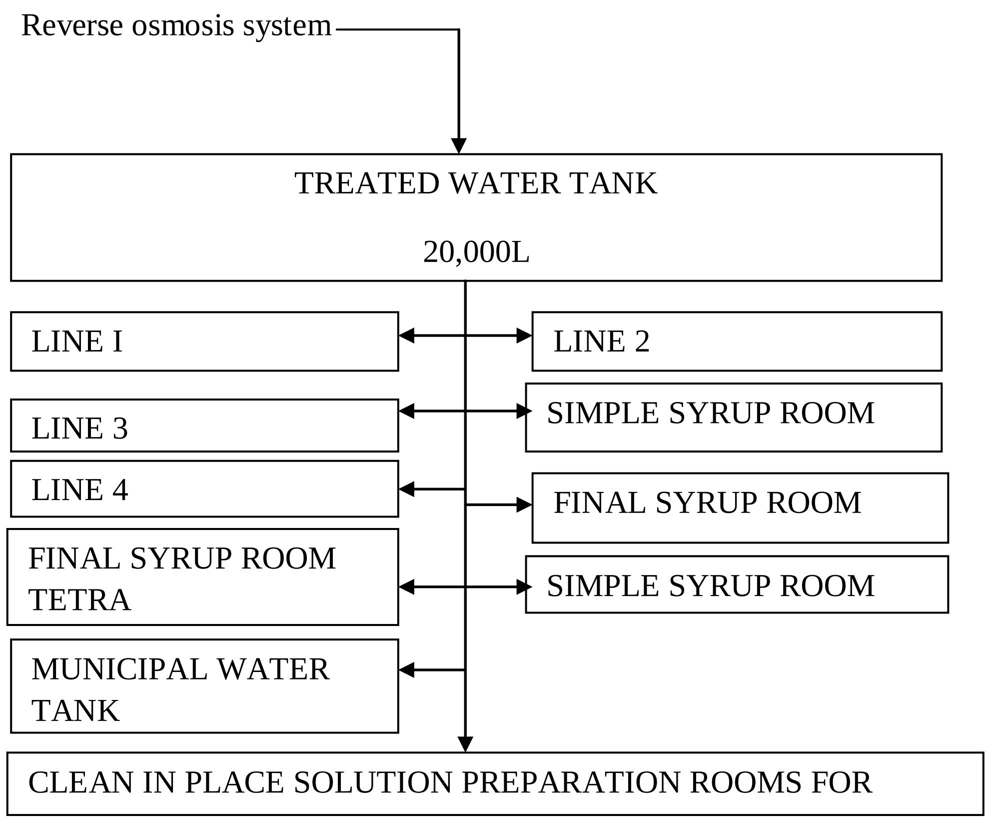


Figure 10 Treated water flow chart in the production areas from the treated water tank

3.2.3.5 Line 1, 2, 3 and 4 treated water flow chart from water treatment

The four lines in the plant draw their water from the borehole treated water tank, from where the water is distributed to the distinct equipment's within the process areas. The equipment's include the paramix that does the blending of the syrup and water, the package rinsing unit, the filling unit, the vacuum pump for the deaerator (remove air from water), the pasteurizing unit and the cleaning hoses within the processing areas. These are as summarized in Fig.11.

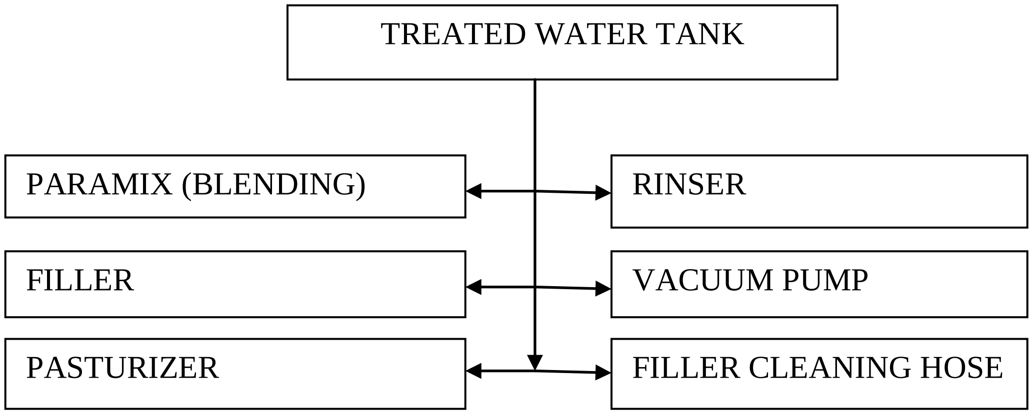


Figure 11 Line 1, 2, 3& 4 treated water flow chart from water treatment

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

Identification of the different units of operation and the construction of individual process flow charts made it easier to generate a material balance. The access to the warehouse raw materials receiving and issuing to production records from the month of January to May 2009 was critical. Access to the production department's reports during the same period on production efficiencies and transfers of finished products to the warehouse was critical too. This was to constitute the benchmark for the entire project. The inputs and outputs data is summarized in Table 9 and a comparison of the two gave an indicator as to how efficient the conversion of the raw materials to finished sellable products was. To have a material balance, several steps were carried out that included establishing how much was put into the process (inputs) and how much came out of the same process after processing (outputs).

4.1 Phase 2: Material Balance: Process Inputs and Outputs

The total input and output for each material was tabulated and the difference between the two taken as the wastage during processing (Table 9). The inputs were fifteen distinct raw materials whose conversion to finish product was evaluated. These raw materials included water, sugar, strategic ingredients, carbon dioxide, and paper among others (Table 9).

4.1.1 Step 4: Inputs Determination

A summary of the material receipt and usage for the month of January to May 2009 were tabulated in Table 9. The data was extracted from the monthly warehouse and production reports. This step was specific to solid raw materials while step five was specific to water usage.

4.1.2 Step 5: Water Usage Determination

The use of water in the entire processing areas was considered in this step of the waste audit. The water usage covered every unit of operation for the month of January to May 2009. The two sources of water, the municipal and borehole supply have separate meters, thus it was easy to generate water consumption volumes for each of the sources separately. Abstraction of water from borehole and municipal is summarized in Table 2.

Table 2 Total water volume from the municipal and borehole supply

MONTH	MUNICIPAL WATER (L)	WELL (L)	TOTAL (L)
JANUARY 2009	327,000	5,939,000	6,266,000
FEBRUARY 2009	450,000	2,982,000	3,432,000
MARCH 2009	487,000	5,872,000	6,359,000
APRIL 2009	221,000	4,973,000	5,194,000
MAY 2009	136,000	7,410,000	7,546,000
TOTAL	1,621,000	27,176,000	28,797,000
PERCENTAGES	5.6%	94.4%	100%

94.4% of the water used in the plant between January and May 2009 was abstracted from the borehole. This means that the 94.4% of the water underwent the treatment process. In the treatment process only 60% was recovered, which is equivalent to 16,305,600 litres. The remaining volume of 10,870,400 litres was rejected from the system and drained into the public sewer. This is summarized in Table 6.

The 16,305,600 litres of treated water above was used in the different units of operations defined earlier, and Table 3 summarizes this usage in line one to three and in warehouses two and three. The data was arrived at by breaking the entire unit process to single subunits that could give accurate data. The individual lines have a rinsing, filling, blending, cleaning units and a separate room for cleaning reagents preparation. Table 3 indicated that the package rinsing process consumed the highest volume of water, 731,440 litres in the units followed by external filler unit rinse water 268,210 liters, conveyor and the cleaning of the entire unit (clean in place) as follows.

Table 3 Water usage for line 1 to 3, raw material and finished products warehouses per month

SR. NO.	**PROCESS**	**LINE 1**	**LINE 2**	**LINE 3**	**WH 2**	**WH 3**	**Total**
1.	Rinser	728,000	1,440	2,000			731,440
2.	Filler external	261,825	2,545	3,840			268,210
3.	Closure Rinser	13,650	250	-			13,900
4.	Paramix	68,250	-	19,200			87,450
5.	Conveyors	196,250	5,220	300			201,770
6.	Cleaning hose	106,166	3,520	500	7,133	12,133	129452
7.	Clean in place	21,233	8,650	50,988		25,766	106,637
8.	Startup, shut down	49,266	2,010	1,200			52,476
9.	Blow molder	200	100	-			300
10.	Wash basins	3,000	100	300	4,736	8,736	12,136
Total		1,447,840	23,405	78,028	11,869	46,635	

The wash room, administration block and the canteen are other areas where water is used. Table 4 summaries the water usage in these areas. Cleaning activity used most of the water with 109,307 litres which is a 36% usage in this activity only and wash room activities taking up the rest.

Table 4 Water Usage in the Wash Room, Administration Block and Canteen

SR. NO.	PROCESS	CHANGE ROOMS	ADM & CANTEEN	TOTAL
1.	Shower room	15,166	2,166	17,332
2.	Urinals	26,208	52,416	78,624
3.	Toilets	36,400	20,800	57,200
4.	Wash basins	30,333	12,133	42,466
5.	Cleaning hose	109,307		109,307
TOTAL		217,307	87,515	304,929

Water utilization in the water treatment area

In the water treatment section a lot of water is used to clean the water treatment individual units in form of a backwash for the sand and carbon filters, followed by a rinsing process for the same and a chemical cleaning for the reverse osmosis systems. This helps to remove accumulated floc on top of the filters to prevent clogging and saturation of floc in the filter thereby resulting to turbid water. Table 5 indicates that more than half a million liters of water is used for this process. Other areas where water is used in the water treatment include preparation of the chlorine (disinfectant) and ferric chloride (flocculation and coagulation) stock solutions.

Table 5 Water usage in the water treatment

SR. NO.	**PROCESS**	**USAGE DURATION**	**QUANTITY / MONTH**	**%**
1.	Cleaning	Twice per day	36,400	6.47%
2.	Chemical preparation	Once per day	1,820	0.32%
3.	Sand filter rinse (2)	Once per day	126,388	22.47%
4	Sand filter back wash(2)	Twice a week	135,720	24.13%
5.	Carbon filter rinse (2)	Once per day	126,388	22.47%
6.	Carbon filter backwash (2)	Twice a week	135,720	24.13%
TOTAL			562,436	100%

4.1.3 Step 6: Measuring Current Levels of Waste Reuse or Recycling

No Water reuse or recycling is carried out at any of the processes defined in this project. The plant quality policy stipulates the use raw treated water as a precaution against cross contamination of products physically, chemically and microbiologically. However, with precautions and proper standard operating procedures, some of the waste generated either through process water or solid waste can be reused or recycled. During the course of the current project, a test on the rinser unit reject water indicated that the water is of better quality both chemically and physically than the municipal supply, thus it can be reused in other equipment's supporting the production process like in the cooling towers. A proposal to reuse this water is tabulated in appendix 1.

4.1.4 Step 7: Accounting For Wastewater

For the wastewater generated.

Wastewater is generated in various sections that include the water treatment process, the filling process and the cleaning process among others.

Table 6 gives a clear picture of the volume of water lost from the reverse osmosis system as concentrate and drained to the public sewer from the month of January to May 2009. The second column has the total water available to the plant for the five months while the third column has the water abstracted from the borehole only. The fourth column indicates the amount of water in liters recovered from the reverse osmosis system and the fifth column indicating the amount of water rejected from the reverse osmosis system then expressed as a percentage of the total water available to the plant in the last column.

Table 6 Percentage Reverse osmosis waste water reject

MONTH	**WELL + MUNI WATER**	**WELL (L)**	**60% RECOVERED**	**40% REJECT**	**% WASTE OF THE TOTAL**
JAN. 2009	6,266,000	5,939,000	3,563,400	2,375,600	37.91%
FEB. 2009	3,432,000	2,982,000	1,789,200	1,192,800	34.75%
MAR.2009	6,359,000	5,872,000	3,523,200	2,348,800	36.93%
Apr. 2009	5,194,000	4,973,000	2,983,800	1,989,200	40.0%
May 2009	7,546,000	7,410,000	4,446,000	2,964,000	40.0%
TOTAL	28,797,000	27,176,000	16,305,600	10,870,400	37.75%

Percentage reverse osmosis waste water for the month of January to May was 37.75% which is the ratio of the total liters of water available to the plant (well water + municipal water supply column 2) and the total liters of water rejected from the reverse osmosis in the same five months period (40% reject column). On average 37.75% of the total water available to the plant is lost during the treatment process through the reverse osmosis system (Table 6). This presented an opportunity to either reuse or recover the water for other uses within the plant.

The second source of waste water are the processes where water is not used as an ingredient for the finished product but used to enhance efficiency and to improve the quality of the products being processed. The volume of this waste water was obtained by comparing the water availed for production after treatment and the final volume of the finished product transferred to the warehouse. Table 7 combines the municipal water supply (column 2) with the processed water from the reverse osmosis system (column 3) to give total water available for production in column four from the month of January to May 2009. Column five has the production output volume in liters for the same duration extracted from the monthly production reports for the five months. Comparison of the total water availed to production (column four) and the production output in liters (column five), yields column six that represent the amount of water used in other processes either in the production process or in the production supporting functions later becoming waste.

Table 7 Process waste water (Jan – May 2009)

MONTH	Municipal Water (L)	Reverse Osmosis Water (L)	Total Water (L)	Production Volume(L)	Process Waste Water	% Waste Water
JAN. 2009	327,000	3,563,400	3,890,400	1,715,142	2,175,258	55.91%
FEB. 2009	450,000	1,789,200	2,239,200	774,336	1,464,864	65.42%
MAR. 2009	487,000	3,523,200	4,010,200	1,369,482	2,640,718	65.85%
Apr. 2009	221,000	2,983,800	3,204,800	1,386,819	1,817,981	56.7%
May 2009	136,000	4,446,000	4,582,000	1,346,665	3,235,335	70.6%
TOTAL	1,621,000	16,305,600	17,926,600	6,592,444	11,334,156	63.2%

Table 7 shows that the percentage wastewater ranged between 56% - 71% from January to May 2009. For the five months the process waste water was 63.2% of the total liters water availed for processing after treatment equivalent to 11.3 million liters.

4.1.5 Step 8: Accounting For Gaseous Emissions

Carbonated products use carbon dioxide to make them fizzy, to introduce taste and also to enhance the flavor of the finished product. After mixing the syrup and water in the specified ratios, the product (beverage) is cooled to below four degrees centigrade and carbon dioxide introduced as it dissolves best at this low temperatures. This occurs best under pressure and if not maintained or there are leakages, a lot carbon dioxide is lost. In Table 8 the carbon dioxide usage from the month of January to the month of May versus what was required is highlighted and the percentage efficiency for the process calculated in the last column.

Table 8 Carbon dioxide usage

Month	**Total CO_2 used (kgs)**	**Expected usage (kgs)**	**% efficiency**
JAN 2009	9600	5208	54.3%
FEB 2009	7200	3252	45.2%
MAR 2009	15400	7340	47.7%
Apr 2009	10700	5087	47.5%
May 2009	10550	5620	53.3%
Total	**53450**	**26507**	**50.0%**

The column two indicating usage for the individual months of January to May and in total fifty three tonnes of carbon dioxide was used. The monthly total was a cumulative data for individual batches usage derived from the carbon dioxide tank weighing scale. The filler operators normally take the scale reading before the run and after completing the batch and by subtracting the two, carbon dioxide usage is attained. The required total amount of carbon dioxide (column three) is calculated based on each specific carbonated product specified formulae carbon dioxide levels. The figure represents an ideal situation where all the carbon dioxide is assumed to have been dosed into the product. A comparison of column two and three gives process efficiency in percentages on how best the availed carbon dioxide is used.

On the overall, only half of the carbon dioxide delivered to the plant was used in the finished product.

4.1.6 Step 9: Quantifying the Process Outputs

4.1.6.1 For the solid waste generated

All raw materials fed into the different processes were considered in this step. The materials included Preforms, Strategic Ingredients, Packs, Cartons, Trays, Shrink, Sleeves, Stretch, Closures, Labels, strips, Best Before stickers, Sugar, Carbon Dioxide, and Water. The raw materials were then processed to finished products that include Coke, Fanta, sprite, minute maid and Dasani. These final products used a specified amount of the raw materials above and it was hence easy to know how much of the input was converted to output as finished product and the difference regarded as waste in the conversion process. The data was extracted from the monthly warehouse and production reports and summarized in Table 9.

Table 9 Process inputs/outputs

SR. NO	MATERIALS	MATERIAL INPUT/ OUTPUT							
		JAN 09	**FEB 09**	**MAR 09**	**APR 09**	**MAY 09**	**TOTAL**	**INPUT – OUTPUT (WASTE)**	**% VAR.**
1.	Preforms (Pcs)	2,167,657 (2,118,720)	919,315 (884,232)	1,343,621 (1,313,064)	1582898 (1,488,048)	1,409,118 (1,381,932)	7,422,609 (7,185,996)	236,613	3.2%
2.	Strategic Ingredients (Units)	845 (832)	429 (393)	692 (682)	711 (688)	667 (661)	3,334 (3,256)	78	2.3%
3.	Packs (Pcs)	121,628 (99,888)	127,836 (109,824)	199,893 (186,940)	88,912 (84,912)	170,568 (153,168)	708,837 (634,732)	74,105	10.5 %
4.	Cartons (Pcs)	7,545 (7,172)	9,499 (9,152)	15,830 (15,579)	7,121 (7,008)	12,913 (12,764)	52,908 (51,675)	1,233	2.3%
5.	Strips (Reels)	9 (9)	0 0	11 (9)	3 (2)	5 (4)	28 (24)	4	1.4%
6.	Trays (Pcs)	136,694 (135,718)	57,579 (57,359)	101,844 (101,301)	109,361 (108,791)	99,538 (99,214)	505,016 (502,383)	2’633	0.5%
7.	Shrink (Kgs)	7,229 (6,988)	2,930 (2,210)	5,708 (5,666)	6,248 (5,734)	5,362 (5,647)	27,477 (26,245)	1,232	4.5%

KEY: VALUES WITHOUT BRACKETS ARE THE TOTAL INPUT FOR EACH MATERIAL FROM JANUARY 2009 TO MAY 2009. VALUES WITH BRACKETS ARE THE TOTAL OUTPUT FOR EACH MATERIAL PROCESS FROM JANUARY 2009 TO MAY 2009

Process inputs/outputs continued

SR. NO.	MATERIALS	MATERIAL INPUT/ OUTPUT							
		JAN 09	**FEB 09**	**MAR 09**	**APR 09**	**MAY 09**	**TOTAL**	**INPUT – OUTPUT (WASTE)**	**% VAR.**
8.	Sleeves (Pcs)	1,294,500 (1,290,996)	371,875 (369,840)	174,250 (172,740)	868,000 (864,654)	642,275 (627,006)	3,350,900 (3,325,236)	25,664	0.8%
9.	Stretch (Kgs)	947 (934)	479 (467)	801 (771)	737 (706)	739 (714)	3703 (3,592)	111	3.0%
10.	Closures (Pcs)	2,129,097 (2,118,720)	891,524 (884,232)	1,321,817 (1,313,064)	1,498,508 (1,488,048)	1,389,594 (1,381,932)	7,230,540 (7,185,996)	44,544	0.6%
11.	Product Labels (Pcs)	2,141,680 (2,118,720)	984,408 (884,232)	1,302,910 (1,313,064)	1,505,022 (1,488,048)	1,390,737 (1,381,932)	7,324,757 (7,185,996)	138,761	1.9%
12.	Best Before stickers (Pcs)	166,100 (142,876)	69,360 (66,511)	115,168 (116,880)	0 (0)	0 (0)	350,628 (326,267)	24,361	6.9%
13.	Sugar(Kgs)	83,371 (81,138)	85,439 (81,119)	160,968 (156,020)	92,883 (90,624)	126,317 (123,789)	548,978 (532,690)	16,288	3.0%
14.	Carbon Dioxide (Kgs)	11,070 (5,208)	9,300 (3,252)	21,830 (7,340)	10,700 (5,087)	10,550 (5,620)	63,450 (26,507)	36,943	58.2 %
15.	Water (L)	6,266,000 (1,715,142)	3,432,000 (774,336)	6,359,000 (1,369,482)	5,194,000 (1,386,819)	7,546,000 (1,346,665)	28,797,000 (6,592,444)	22,204,5 56	77.1 %

KEY: VALUES WITHOUT BRACKETS ARE THE TOTAL INPUT FOR EACH MATERIAL FROM JANUARY 2009 TO MAY 2009. VALUES WITH BRACKETS ARE THE TOTAL OUTPUT FOR EACH MATERIAL PROCESS FROM JANUARY 2009 TO MAY 2009

A comparison of the input numbers with the output numbers resulted in waste generated. In Table 9, the last column summarizes waste in percentage. Water usage had the highest wastage at 77.1% partly contributed by the fact that 94% of the total water used in the plant is abstracted from the borehole and has to be treated through a reverse osmosis system that rejects 40% of the feed water Table 6. The 37.1% balance is lost in the production process. Carbon dioxide usage had 58.2% waste. This is a huge loss considering that the company does not generate carbon dioxide on site but purchases the material from a third party. The third raw material with 10.5% loss was the packs on the tetra line. At number four were the 'best before' stickers with 6.9% loss. The project evaluated the necessity of the sticker and after consultation with the management the stickers were done away with. The stickers had the same information as individual packs. Shrink was fifth with a loss of 4.5%. Preforms were sixth with 3.2% waste. At the seventh position was the sugar, followed by the stretch wrap, strategic ingredients, cartons, labels, strips, sleeves, closures and at number fifteen trays.

All the materials' waste evaluated above, had some financial impact to the company. The magnitude of the financial impact was not the same for all the materials evaluated. It is on this basis that water, strategic ingredients, preforms, carbon dioxide, packs and sugar were picked to proceed to the waste reduction stage.

4.2 Step 10: Accounting for Offsite Wastes treatment

Offsite waste is the solid or liquid waste that could not be reused, recycled or recovered was at the plant level but an external contractor was involved in its disposal. The waste was weighed in kilos and recorded in shipping manifest and then compiled to give Table

10. The solid materials and the water treatment chemicals and other processing aids are brought to the plant by suppliers in special packages which are discarded after the operators remove the raw materials or chemicals. The management of these raw materials' and chemicals' package wastes was critical to realize a reduction in offsite treated waste. The waste included pallets, preform cartons, waste preforms, sugar bags, closure and strategic ingredients small cartons, metal drums among others listed in Table 10. Table 10 was generated using waste disposal shipping manifest forms data generated by weighing the different waste. The data was compiled on a daily basis, yielding a monthly report of all the waste disposed from the company in that month. One of the companies dealt with waste that could be recycled while the other dealt with waste that was taken to the dump site. The project identified a waste accumulation area where all the waste from the plant could be put awaiting daily sorting by the two companies. The recyclables were sold to this company and as for the waste to the dump site, the company paid for its disposal. At the end of the day, a waste manifest for the recyclable material and waste to the dump site was generated. The data generated was used as a bench mark to monitor the rate of waste reduction at the source after the implementation of this project.

The recyclable materials included damaged pallets, preforms cartons, sugar bags, small cartons, plastic pipes, plastic containers, waste preforms, glass bottles, polythene papers, chip boards, metal drums, scrap metals, and preform bags. The total recyclable materials in Table 10 generated income to the company totaling to half a million shillings. Waste preforms constituted 18% of the total waste in Table 10 translating to more than three million shillings hence a loss to the company when they were disposed at forty thousand shillings only. A waste reduction in this area presents an opportunity for a huge saving of more than three million Kenya shillings to the company annually.

Table 10 Offsite waste treatment (Kgs)

WASTE	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Total**
Damaged Pallets	3,855	2,490	1,380	2715	555	10,995
Preform Cartons	747.5	379.5	103.5	621	0	1,851.5
Sugar Bags	140	170	286	170	198	964
Small Cartons	327	189	229.5	102	18	865.5
Plastic Pipes	204	0	48	244	91	587
Plastic Containers	194	212	402	192	260	1,260
Waste Preforms	937	855	1,539	2519	2160	8,010
Glass Bottles	125	50	65	57.2	82.5	379.7
Polythene Paper	182	401	627	1053	626	1,679
Chip Boards	225	0	0	15	900	1,140
Metal Drums/ Scrap	1,695	1,380	2,880	1140	1665	8760
Preforms Bag	825	570	225	0	130.5	1,750.5
Solid Waste To Landfill	450	350	650	750	850	3,050
TOTAL	9,906.5	7,046.5	8,435	9578.5	7536	42,502.5

4.3 Phase 3: Synthesis

In phase one the pre-assessment involving audit preparation and breaking down the processes into different units of operation made it easier to have phase two. The subsequent steps in phase two led to the building of information on all raw materials input to the processes, and after processing, the outputs from the same processes were evaluated. The analysis of the inputs and outputs data in the two phases resulted in a refined material balance from the month of January to May 2009 (Table 9). The data in phase three was digested accurately and used to support the need for a reduction of waste at the source. It had five steps that included individual raw material process audit, identification of obvious waste reduction measures, waste segregation to enhance reuse and recycling, undertaking long term waste reduction measures and action plans and finally evaluation of the environmental and economic gains attained after the implementation of the project.

To select the materials in Table 9 to proceed to phase three, two factors were considered; first, the volume of waste generated and second the financial impact the waste generated has on the company finance. It is on this basis that water, strategic ingredients, preforms, carbon dioxide, packs and sugar were picked to proceed to the waste reduction stage. Preforms had the greatest financial impact of 2.7 million shillings followed by strategic ingredients with 2.6 million shillings, water 2.1 million shillings, carbon dioxide 1.5 million shillings, packs 1.5 million shillings and sugar 0.8 million shillings. The raw materials selected are summarized in table 11.

Table 11 Waste reduction materials

SR. NO.	MATERIALS	TOTAL INPUT	TOTAL OUTPUT	WASTE	% WASTE
1.	Preforms (Pcs)	7,422,609	7,185,996	236,613	3.2%
2.	Strategic ingredients (Units)	3,334	3,256	78	2.3%
3.	Packs (Pcs)	708,837	634,732	74,105	10.5%
4.	Sugar	548,978	532,690	16,288	3.0%
5.	Carbon Dioxide	63,450	26,507	36,943	58.2%
6.	Water	28,797,000	6,592,444	22,204,556	77.1%

The summary of the percentage waste (Table 9) established the areas that need to be concentrated on for meaningful environmental and economic gain. All the sources of waste for the individual raw material input process had different requirements to close the gap and create a waste free environment. Some engagements required financial input while some did not. Some required creating awareness to the staff and communicating the process performance to them for continuous improvement. For some to close the gap, a budget had to be allocated and approved by the board before the implementation. This required the presentation of facts indicating how much the project will cost, versus the payback period. It was thus easy to start with the implementation of activities that were less demanding as stipulated in waste reduction measures in the next step.

To have a successful waste minimization program, crucial activities had to be identified and they included; establishing the role of everyone within the company and especially the operational staff involved in the processing of raw materials to finished products. The management had the role to provide the necessary resources to reduce waste at the source.

To start the process of reducing waste at the source, a waste audit for the individual raw materials was carried out to establish the category of waste based on a Japanese model Operational Excellence (OE) that has eight categories of waste all developed from the activity leading to generation of that waste and include Defect, Overproduction, Waiting, Not embracing change, Transportation Inventory, Motion and Excess processing (Table 12).

Table 12 Categories of Waste

CATEGORY OF WASTE	NUMBER	CATEGORY OF WASTE	NUMBER
Defect	1	Transportation	5
Overproduction	2	Inventory	6
Waiting	3	Motion	7
Not Embracing Change	4	Excess Processing	8

Category one is waste due to a defect in the processing equipment's thus generating products that are not conforming to the process specification, or damaging of raw materials before or during processing. The second category of waste defined under OE is, not embracing change, a failure by the system for instance not to automate its operation and eliminate manual handling of materials that can lead to waste generation. The third category of waste is due to performance of a lot of unnecessary movements on a task. A good example is a receptionist lifting phone calls from a hand set all day long will generate waste on time compared to a receptionist with a telephone receiver placed as a head gear. The fourth category of waste involved keeping too much inventory in the warehouse such that some get damaged, others expire or the quality deteriorates thus becoming obsolete. The fifth category of waste is waiting, where one has to idle and wait for the other processes to be completed first. The sixth category of waste is excess processing where a cleaning process rinsing step is sufficient if done for five minutes and the operator decides to take ten minutes thus wasting water. The seventh category of waste is overproduction where a system plans to produce more than the market requires thereby ending up with product expiring in the warehouse or in the trade. The eighth and last category of waste is transportation and involves unplanned movement of raw materials and finished products in the warehouse and in the process damages arise hence waste. Some of these categories of waste were not applicable to this project like waiting which has a direct impact on the pay roll but not to generation of waste at the source.

After the categories of waste were established, the waste generation area, the process involved and waste description, the quantity of wastes generated per year were defined and tabulated in Table 13 for the preforms. Depending on the nature of the process, a remedy for the individual waste was identified. The remedies were classified into two, depending on whether it would be a quick remedy (Y) that would take less time and money or one which would require more time and resource allocation (N) as highlighted in Table 13.

The waste audit was conducted for the entire six chosen raw materials inputs. The waste audit report made it easier to work with the operators and came up with a list of activities that could be carried out to reduce waste generation at the source. These activities were listed and implemented for the six raw materials. After the implementation of the waste reduction measures, the process performance was subjected to a continuous monitoring program, and the results tabulated and compared to the tabulated data in Table 9, for the same material for the months of January to May 2009 when a waste reduction program was not in place.

In a nut shell, the six inputs to the processes i.e. preforms, sugar, strategic ingredients, packs, carbon dioxide and water waste reduction program had; a waste audit report, a list of activities to remedy the waste generation and tabulated results benchmarked against the performance of the process during the months of January to May 2009. Below are steps for the individual raw materials.

4.3.1 Preforms raw materials analysis

Table 13 summarizes the audit report for the preforms and covered the receipt of the preforms from the supplier to the warehouse. Based on the production plans, the preforms are issued from the warehouse to the production blow molding machine where they are blown to bottles. The bottles pass through an air conveyor to the rinsing process, filling, capping, date coding, labeling, case packing, palletizing and finally, the finished product is transferred to the finished products' warehouse for distribution to the market.

The second column of Table 13 identifies the location of waste generation area while column three identifies the process type. Column four gives a description on how this waste is generated, the fifth column on the table has the categories of waste and column six quantifies the annual waste. In the last column, the audit tried to estimate how long or how fast it could take to fix the problem. For a quick win (quick remedy that would take less time and money) it was a yes (Y), if not a quick win (required more time and more resource allocation) it was a no (N).

4.3.1.1 Preforms audit report

Table 13 Preforms audit report

SR. NO	Location of Waste	Process	Description of Waste	Cat. of Waste	QTY PER YR	Quick-win (Y/N)?
1	Warehouse	preform transport	scoping preforms in the warehouse to transport - some fall	4	14,680	Y
2	Warehouse	preform transport	during the transportation stage some fall also - poor containers	4	7,655	Y
3	Warehouse	preform transport	transferring from the carton at the blow molding hopper some fall	4	6,900	Y
4	Blow molder area	BM heating section	at the oven ejecting unit spillage	1	5,400	Y
5	Blow molder area	Blowing process	poor preform quality leading to defective blown bottles	1	6,120	Y
6	Blow molder area	Blowing process	compressor failure - machine stops - preforms lost	1	2,350	N
7	Blow molder area	Blowing process	Power failure - machine stops - preforms lost	1	27,872	N

KEY: Category of waste

1: Defect 2. Overproduction 3. Waiting 4. Not embracing change

5. Transportation 6. Inventory 7.Motion 8. Excess processing

Table continued,

SR. NO.	Location of Waste	Process	Description of Waste	Cat. Of Waste	Qty Per Yr	Quick-win (Y/N)?
8	Blow molder area	Blowing process	cooling failure - machine stops - preforms lost	1	3,450	N
9	Blow molder area	Blowing process	Mechanical failure - machine stops - preforms lost	1	34,680	Y
10	Conveyor	air conveyor	bottles falling from the air conveyor	1	2,343	Y
11	Filling hall	rinsing process	bottles falling on the rinser table	1	2,675	Y
12	Filling hall	filling	bottles falling on the filler table	1	1,760	Y
13	Filling	filling	Overfilling	1	13,560	N
14	Filling	filling	under filling	1	176,235	N
15	Filling	filling	hanging closures	1		N
16	Filling	filling	non conforming products	1		Y
17	Conveyor	transport	bottles falling on the conveyor - line stoppage	1	3,570	Y

KEY: Category of waste

1: Defect 2. Overproduction 3. Waiting 4. Not embracing change

5. Transportation 6. Inventory 7.Motion 8. Excess processing

Table continued,

SR. NO.	Location of Waste	Process	Description of Waste	Cat. of Waste	Qty Per Yr	Quick-win (Y/N)?
18	Conveyor	transport	Double date coded bottles	1	1,120	Y
19	Filling process	MC operation	machine bottle crushing	1	2,150	Y
20	Warehousing	storage	product expiring in the warehouse	2	500	Y
21	Warehousing	storage	poor storage conditions	1	150	Y
22	Warehousing	storage	poor handling practices	1		Y
TOTAL					**313,170**	

KEY: Category of waste

1: Defect	2. Overproduction	3. Waiting	4. Not embracing change
5. Transportation	6. Inventory	7.Motion	8. Excess processing

The categories of waste contributing to a high preforms losses was, defects, which was number one, followed by the company's failure to embrace change that include adapting new technology in the blowing process operation which was number four. In terms of processes, the filling process had the highest waste on preform at two hundred thousand pieces. The problem was due to the malfunctioning of the mixing unit, rinser and the capping unit. The mixing unit does the blending of the syrup and water in a specific ratio and in the same unit carbon dioxide is dosed into the beverage. Any deviation from these specifications yields a non-conforming product that cannot be sold, hence destroyed. The rinser can have bottle losses through crashing at the in feed or having a worn out gripper leading to bottle falling on the filling table. The capping unit puts a closure on the bottle after the filling process. The bottle and the closure must be aligned such that when they meet there is no deviation angle that can lead to a hanging closure. A package with a hanging closure will leak and therefore be removed from the line before labeling at the sighting station.

The next process with high preform wastage was the blow molding process with over eighty thousand preforms lost. This was largely due to machine malfunction and power failures during the production processes. The manual handling of the preforms was also contributing eighty thousand pieces of preforms waste. Fixing of the above two areas would save at least two hundred thousand preforms. This could be achieved through good maintenance practices and training of the operators on material handling.

Figure 12 is a plate of good bottles that were falling on the filling table after rinsing due to worn out grippers. Repair or replacement of the bottle grippers could solve the problem.

Figure 12 Fallen bottles on the filling table

After the areas in which waste is generated were identified, the next step was to highlight some activities that could be implemented, to reduce the waste generated.

4.3.1.2 Preforms Activities

A number of activities were identified to attain a reduction in preform waste and they included; training of all the staff members involved directly in the handling and processing of the preforms to finished product. The training was to create awareness on the financial and environmental impacts arising from the preforms waste generated in the plant. The trained operators were issued with proper containers to carry preforms where manual handling of the material was inevitable. The blow molding machine operators were trained on quick parameter setting for the blowing process and the best parameters recorded and kept for future reference. The same operators accepted to take preform yield as one of their key performance indicators, thereby increasing their zeal for continuous improvement.

Maintenance of the blow molding machine, forklifts, air conveyor, rinsing unit, filling unit and downstream equipment's was key to the realization of the waste minimization goal. A maintenance schedule of all the equipment highlighted above would make sure that the entire operation was in focus, without overlooking any material handling equipment. A stock verification of the key spare parts of these equipment's was raised, and actions generated to ensure that they would always be available when required and are used immediately the process is generating waste due to process performance failure. After carrying out all these activities, a saving of over two hundred thousand preforms was realized. The result of the implementation of the activities above is indicated in Figure 13.

4.3.1.3 Preforms yields trend after implementation of a source waste reduction

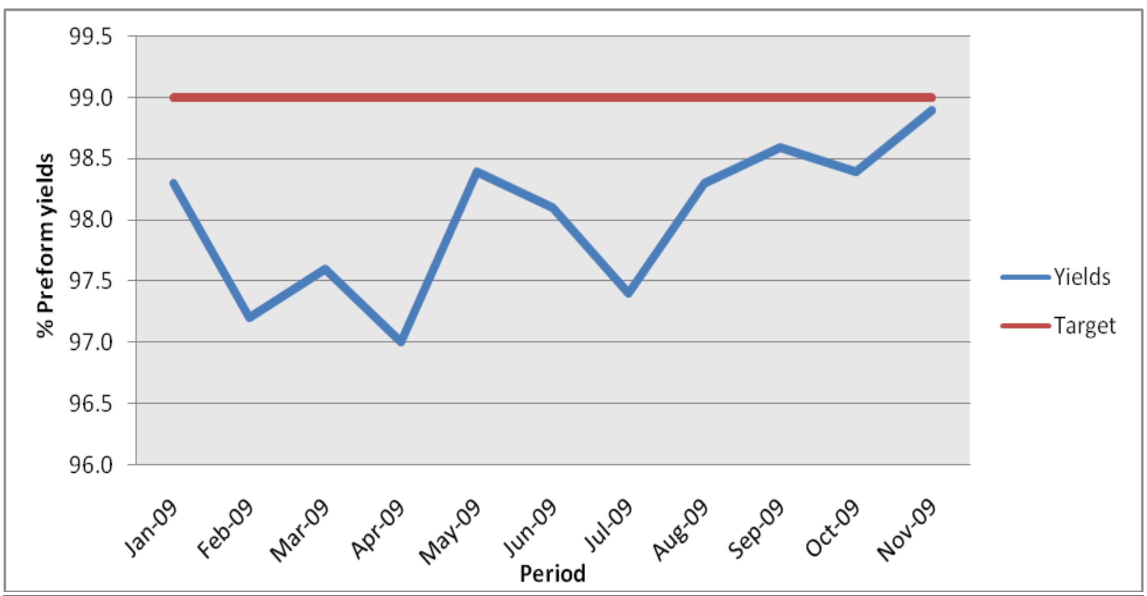


Figure 13 Preforms yields 2009

The preforms yield indicated a general progressive improvement Figure 13. The average preforms yield from the month of January to April 2009 was 97.7%, Figure 13. From the month of May to November, the yields improved to an average of 98.3% thus a positive 0.6% improvement equivalent to a savings of 59,000 pieces of preforms. This is the period where the above mentioned source waste reduction measures were implemented. In monetary terms, this is equivalent to more than half a million Kenya shillings, thus saving (Kshs.531, 000) in seven months only (Table 14). Annually the company can therefore realize a saving of more than nine hundred thousand shillings.

Table 14 Preform savings

	Actual	Target	% Yield
Total preforms used Jan to April	5,943,418	5,804,064	97.7%
Total preforms used May to Nov.	8,978,350	8,829,612	98.3%

The activities carried out here were quick fixes that required little financial input. The Year 2010 target is to carry out an overhaul of the entire bottle forming equipment, in order to realize higher savings.

4.3.2 Sugar and Strategic Ingredients

The strategic ingredients came second after preforms on the financial impact to the company with an estimated loss of approximately 2.6 million shillings in six months. The strategic ingredients and sugar materials processes follow the same sequence, since the two are mixed to form the final syrup. Once the final syrup has been prepared, the two raw materials undergo the same processing steps as a unit to final product which is stored in the finished goods warehouse. An audit was carried out and summarized in Table 15.

4.3.2.1 Strategic Ingredient and Sugar Audit Report

Table 15 Strategic Ingredient and Sugar Audit Report

SR. NO.	Location of Waste	Process	Description of Waste	Category of Waste	Qty Per Yr(Kgs)	Quick -win (Y/N)
1	warehouse receiving	Receiving	verification of what has being delivered	6	7,392	Y
2	Warehouse	Transport	forklift or pallets damaging the sugar bags hence spillage	4		Y
3	Warehouse	Storage	poor storage conditions	4		Y
4	Warehouse	Dumping	sugar spillage during weighing and dumping using a forklift	6	4,500	Y
5	Sugar dumping area	Dumping	sugar remaining in the sugar bags after dumping	6		Y
6	Simple syrup room	Filtration	spillage during the filtration process- loose elbows	1		Y
7	Simple syrup room	Filtration	poor simple syrup pushing to the final syrup tank through the filters	1		Y
8	Simple/final syrup room	Filtration	the presence of leaking valves	1		Y
9	Filling hall	start up	poor start up process- use a lot of final syrup to rinse the system	1		Y

KEY: Category of waste

1: Defect 2. Overproduction 3. Waiting 4. Not embracing change

5. Transportation 6. Inventory 7.Motion 8. Excess processing

Table continued,

SR. NO.	Location of Waste	Process	Description of Waste	Category of Waste	Qty Per Yr(Kgs)	Quick -win (Y/N)
10	Filling hall	start up	improper setting leading to syrup waste	1		Y
11	Filling hall	start up	improper cooling of the system leading to product loss	1		Y
12	Filling hall	Filling	overfilling - sugar loss	1		N
13	Filling hall	Filling	under filling - sugar loss	1		N
14	Filling hall	Filling	hanging closures	1		N
15	Filling hall	transport	Double date coded bottles	1	11,500	Y
16	Filling hall	Machine operation	machine bottle crushing	1		Y
17	Filling hall	Filling	poor shutdown up process- water sugar interface	1		N
18	Warehousing	Storage	product expiring in the warehouse	2	154	Y
19	Warehousing	Storage	poor storage conditions	1	35	Y
20	Warehousing	Storage	poor handling practices	1	145	Y
TOTAL					39,426	

KEY: Category of waste

1: Defect 2. Overproduction 3. Waiting 4. Not embracing change

5. Transportation 6. Inventory 7.Motion 8. Excess processing

Waste category number one still had the largest waste at about 70% followed by not embracing waste.

The audit findings indicated that during receiving, transportation and storage of the materials, more than seven tonnes of sugar are lost. As shown in Table 15, in the preparation of the simple syrup and the final syrup a loss of four and a half tonnes of sugar was realized annually. The filling operation resulting in non-conforming products was leading to a loss of more than twenty seven tonnes of sugar and forty units of strategic ingredients. Therefore, actions leading to a reduction in sugar and concentrate wastage were to address the warehousing practices, the syrup preparation and the filling process. Warehousing waste came from poor handling of products resulting to damages of the package, failure by the warehouse staff to use the proper stock rotation method (first expiry first out), leading to product expiries in the warehouse. Syrup preparation on the other hand generated waste through spillage of strategic ingredients, and sugar for example during the filtration process. In the filling process blending and getting a non-conforming product that has sugar and the strategic ingredient is a waste as the product will not be for sale. In the filling unit, under filling products, to yield half fills and overfills, is also a source of waste. Double- date coding of the package creates confusion to the customer and it is thus treated as a non-conforming product generating waste. Figure 14 shows some ‘on line’ rejected under - filled products and ‘in the process’ loss on strategic ingredients and sugar.

Figure 14 Rejected Non-Conforming products

4.3.2.2 Strategic Ingredient and Sugar waste reduction Activities

Activities carried out to address these wastages include; verification of all deliveries of sugar from the supplier and development of procedures to ensure that good warehousing practices were operational. These good warehousing practices include, taking care of half-filled sugar bags, avoiding the use of water in cleaning of the sugar store and pest control to avoid contamination. Other measures involved training syrup preparation operators on waste minimization, use of mixing instructions to avoid spillage and use of the correct cleaning methods to avoid cross contaminating products.

On the filling operations, start up and shut down procedures were developed and the operators trained on them. The procedure elaborates the steps involved during the initial introduction of a product to the mixing and filling equipment without compromising its quality. The procedure during the starting and shutting of the line was to deal with the water interface as cleaning happens before any production and rinse water remnant can alter the product specification. At the end of the production, the last part of the product in the pipes is pushed to the mixing equipment with water. The water /final syrup interface is cautiously monitored and this procedure ensures syrup optimization at this stage. To reduce these losses, the mixing and filling machines' maintenance schedule was developed. Also, the availability of critical machine spare parts was verified as sometimes the machines were running when some parts had failed. The results after implementation of the above measures are as shown in Fig. 15.

4.3.2.3 Trend of strategic ingredient and sugar yields before (Jan-May) and after (June- Nov) implementation of the source waste reduction measures

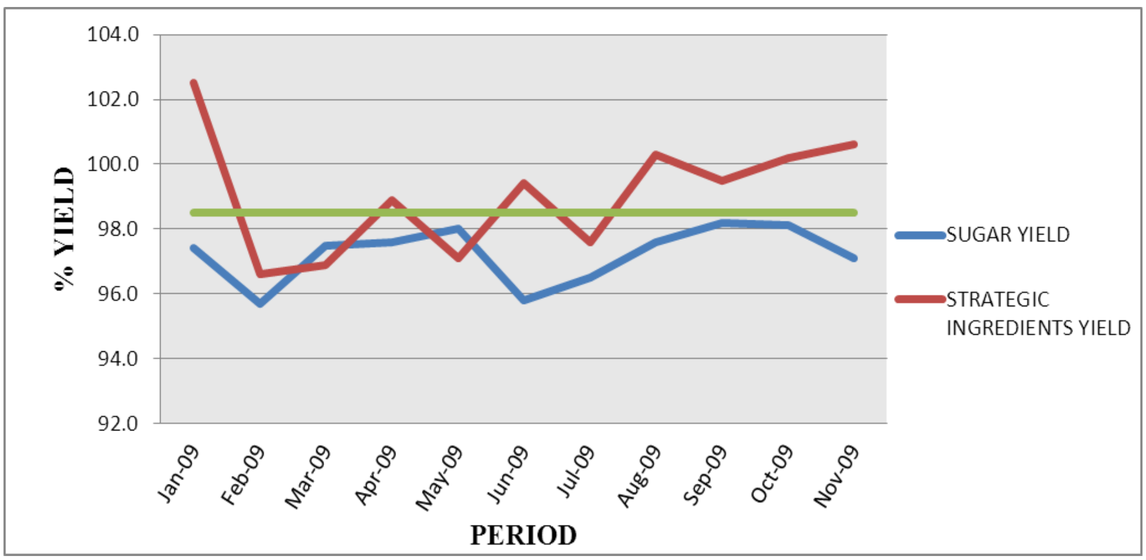


Figure 15 Trend of strategic ingredient and sugar yields before (Jan-May) and after (June- Nov) implementation of the source waste reduction measures.

The graph shows a very weak yield improvement on sugar from the month of January 2009 to November 2009. The month of February had a decline in sugar and strategic ingredients yields, due to malfunctioning of the mixing equipment which led to the production of non-conforming products. During the same month, concentrated fruit flavored cordials were produced, which normally use a lot of sugar, and a small syrup loss therefore has a significant impact on the strategic ingredients and sugar. During the entire project period, the sugar yields remained relatively below the set target due to many elements of the processing equipment malfunctioning and these could not be easily controlled. However ,there was a gradual improvement from the month of June (95.9%) to the month of September (98.2%).The month of October and November showed a decline in sugar yields due to the filling machine malfunctioning, hence yielding many under fills and packages with hanging closures.

Table 16 Sugar savings

	Actual	Target	% Yield
Total sugar used Jan to March 2009	328,571	318,707	97.00%
Total sugar used April to Nov. 2009	753,243	732,541	97.25%

This was a slight improvement of 0.25% that translates to two tonnes savings for the eight months as indicated in Table 16.

Strategic ingredients on the other hand yields were poor during the month of February as it was a drop from the month of January due to the same reasons given above for sugar. March to June gave no progressive yields improvement. July to November had a progressive increase from 96.7% to 100.4 %. This was largely due to a high volume of products without sugar done during this month. Still, water production uses only one strategic ingredient and it has no sugar. The yields are always above 100%, because the product is not carbonated that will make a product foam, the product is filled at room temperature and does not require special filling temperatures and the still water volumes are huge hence long runs which reduces the number of times your start and shut down the filling process. More production of still water than carbonated products improves the overall strategic ingredients yields.

4.3.3 Waste Water Reduction

Waste water came third with a 2.1 million shillings financial impact. Waste water had two sources, the reverse osmosis system with 10.9 million liters (Table 6) of waste water and process waste water at 11.3 million litres (Table 7), out of a total water supply of 28.8 million litres for the January to May 2009 duration which translates to 77.1% loss. The results are summarized in Table 17.

4.3.3.1 Waste Water audit report

Table 17 Waste water Audit Report

SR. NO.	Location of Waste	Process	Description of Waste	Category of Waste	QTY PER YR(L)	Quick-win (Y/N)
1	water treatment area	water treatment	semi treated water tank outlet valve leakage	1	75,650	Y
2	water treatment area	water treatment	uv - water recirculation pump leakage	1	45,785	Y
3	water treatment area	water treatment	reverse osmosis reject not recovered	4	26,162,960	N
4	water treatment area	water treatment	Reverse osmosis vessel no 2 water leakage	1	235,440	Y
5	water treatment area	water treatment	Reverse osmosis vessel no 3 water leakage	1	250,750	Y
6	water treatment area	water treatment	sand filter backwash water not recovered	4		N
7	water treatment area	water treatment	sand filter rinse water not recovered	4	2,145,296	N
8	water treatment area	water treatment	carbon filter backwash water not recovered	4		N
9	water treatment area	water treatment	carbon filter rinse water not recovered	4	2,145,296	N
10	water treatment area	water treatment	general cleaning hose has no restrictor	4	46,800	Y

KEY: Category of waste.

1: Defect 2. Overproduction 3. Waiting 4. Not embracing change

5. Transportation 6. Inventory 7.Motion 8. Excess processing

Table continued,

SR. NO.	Location of Waste	Process	Description of Waste	Category of Waste	QTY PER YR(L)	Quick -win (Y/N)
11	water treatment area	water treatment	ozone generator plastic piping leaking out water	1	95,350	Y
12	TTA simple syrup room	simple/final syrup preparation	simple syrup transfer pump cooling water not recovered	4	35,454	Y
13	filling hall	simple/final syrup preparation	the simple syrup line too long	5		N
14	filling hall	simple/final syrup preparation	steam condensate not recovered	4		N
15			process water at the pasteurizer	4		
16	filling hall	pasterization/ filling	process water at the filling unit that is not recovered	4		N
17	filling hall	pasterization/ filling	filler water during production discarded	4		N
18	packing hall	transportation	water on the conveyor not recovered	4		N
19	packing hall	transportation	water on the conveyor not regulated	4		N
20	Blowmolder area	blow molding	cooling water leakage at the blow molding section	1	836,336	Y

KEY: Category of waste.

1: Defect 2. Overproduction 3. Waiting 4. Not embracing change

5. Transportation 6. Inventory 7.Motion 8. Excess processing

Table 17 continued,

SR. NO.	Location of Waste	Process	Description of Waste	Category of Waste	QTY PER YR(L)	Quick -win (Y/N)
21	Ozonation	ozonation	water leak at the ORP station	1		Y
22	rinser	rinsing bottle	rinse water not recovered	4		N
23	rinser	rinsing bottle	rinse water valve left open through out	4		Y
24	rinser	rinsing bottle	rinser central column leaking water	4		Y
25	rinser	rinsing bottle	filler external cleaning water not recovered	4	9,274,080	N
26	De aerator	water de aeration	vacuum pump cooling water not recovered	4		N
27	Cooling	cooling	water misuse due to icing on the cooling system	1		Y
28	Cleaning	cleaning	cleaning hose has no flow restrictor	4		Y
29	Cleaning	cleaning	cleaning hose used to top up municipal water tank with water	4		N

KEY: Category of waste.

1: Defect 2. Overproduction 3. Waiting 4. Not embracing change

5. Transportation 6. Inventory 7.Motion 8. Excess processing

Table 17 continued,

SR. NO.	Location of Waste	Process	Description of Waste	Category of Waste	QTY PER YR(L)	Quick -win (Y/N)
30	rinser	rinsing bottle	the rinser selonoid valve connection poit leaking water	1		Y
31	production areas	cleaning	cleaning the floor with a hose that has no flow restrictor	4		Y
32	simple syrup preparation area	simple syrup preparation	simple syrup transfer pump cooling water not recovered	4	465,240	N
33	simple syrup preparation area	simple syrup preparation	cleaning hose has no flow restrictor	4	45,780	Y
34	KHS syrup rooms	KHS CIP SYSTEM	CIP solution interface not recovered	4		N
35	KHS syrup rooms	KHS CIP SYSTEM	CIP rinse water not recovered	4		N
36	KHS syrup rooms	KHS CIP SYSTEM	cooling water after sterilization not recovered	4	3,367,985	N

KEY: Category of waste.

1: Defect 2. Overproduction 3. Waiting 4. Not embracing change

5. Transportation 6. Inventory 7.Motion 8. Excess processing

Table continued,

SR. NO.	Location of Waste	Process	Description of Waste	Category of Waste	QTY PER YR(L)	Quick -win (Y/N)
37	AVE line CIP pre. Room	AVE CIP SYSTEM	CIP solution interface not recovered	4		N
38	AVE line CIP pre. Room	AVE CIP SYSTEM	cooling water after sterilization not recovered	4		N
39	AVE line CIP pre. Room	AVE CIP SYSTEM	the CIP procedure not followed to the letter - over doing it	4	7,659,860	N
40	KHS final syrup room	final syrup preparation	Final syrup transfer pump cooling water not recovered	4	387,564	N
TOTAL					53,201,626	

KEY: Category of waste.

1: Defect 2. Overproduction 3. Waiting 4. Not embracing change

5. Transportation 6. Inventory 7.Motion 8. Excess processing

In the water usage, not embracing change has the highest wastage followed by defects. This implies that on water usage, the management needs to have a completely different approach to design processes that are environmentally friendly in water usage. Table 17 indicates that water treatment had the largest waste water annual volume loss of 30.5 million litres. Out of these, 26.1 million liters was the reverse osmosis reject water (Fig 16) with high mineral content. The chemical parameters of this reject water indicated the presence of high salt content evident from the high conductivity results observed of over 2000µs/cm compared to the treated water of less than 20µs/cm. The treatment of this reject water would require a process that can withstand chemical corrosion and clogging from precipitation and scaling. During the evaluation of the obvious waste reduction measures, no single activity could be undertaken on this without some investments. Other parties are using the reverse osmosis reject water to recharge the aquifer or passed through another treatment process like ion exchange treatment and further filtration using special types of membranes used in sea water desalination. The same reject water has been mixed with borehole water in specified ratios and passed through the same water treatment process but after some duration a one day rejection necessary to break the cycle and this is dependent on the quality of water.

The cleaning process for the process equipment's on the other hand had 11 million litres of waste water. The cleaning cycle is done after production of every batch and has the rinsing step that takes ten minutes, followed by introduction of hot caustic which is circulated for fifteen minutes at 85°C.Then a caustic rinse taking ten minutes, hot water sterilization with circulation for fifteen minutes at above 90°C, and lastly the cooling of the process equipment to room temperature. The above step is carried out on all the process equipment, and an optimal cleaning detergent pressure, must be maintained throughout the cleaning cycle. At the time of the project, the flow was maintained at $10M^3$ per hour. In between the steps, tests are carried out to ensure that no chemical residues carry over to the next step. The cleaning process between caustic rinse and hot water sterilization cycle can be optimized and the process waste water recovered for use in other processes like the cooling of equipments as per the proposal attached in appendix 1. Other parties are moving away from the use of caustic based detergents to chlorine based cleaning reagents.

The rinsing process at the filling area was third with 9.3 million litres of waste water half of which came from the bottle rinsing process. In the other process equipments, the treated water is used as a lubricant on moving parts. This water was sampled, analyzed and found to be of a superior quality both physically and chemically as per Appendix A1 Table 1. This water can be tapped and reused in other processes.

Figure 16 Reverse osmosis water rejects area

4.3.3.2 Waste water reduction activities

Overall the company needs to reduce the total demand for water and implement all necessary projects to conserve, reuse or recycle water with a payback period of between

1 to 3 years. In this project, the activities carried out included fixing all leaks, evaluation and adjustments on water to optimize flow rates, and spray patterns on the rinser, pump cooling, clean in place processes and line lubrication. Solenoid valves were introduced on the rinser to prevent continuous flow of water while for the cleaning hoses, restrictors and solenoid were connected. The use of buckets and mops to prevent misuse of water was also encouraged. Reuse of spent conveyor lubrication water in non-critical plant operations like floor cleaning was initiated. The clean in place procedure was reviewed to recycle most of the cleaning solutions in a loop.

Water use awareness campaign was carried out in the plant by putting water usage pictures on the factory wall, see appendix 3. After the implementation of the above activities, the trend in water usage is summarized in Figure 17.

4.3.3.3 Waste water reduction activity results

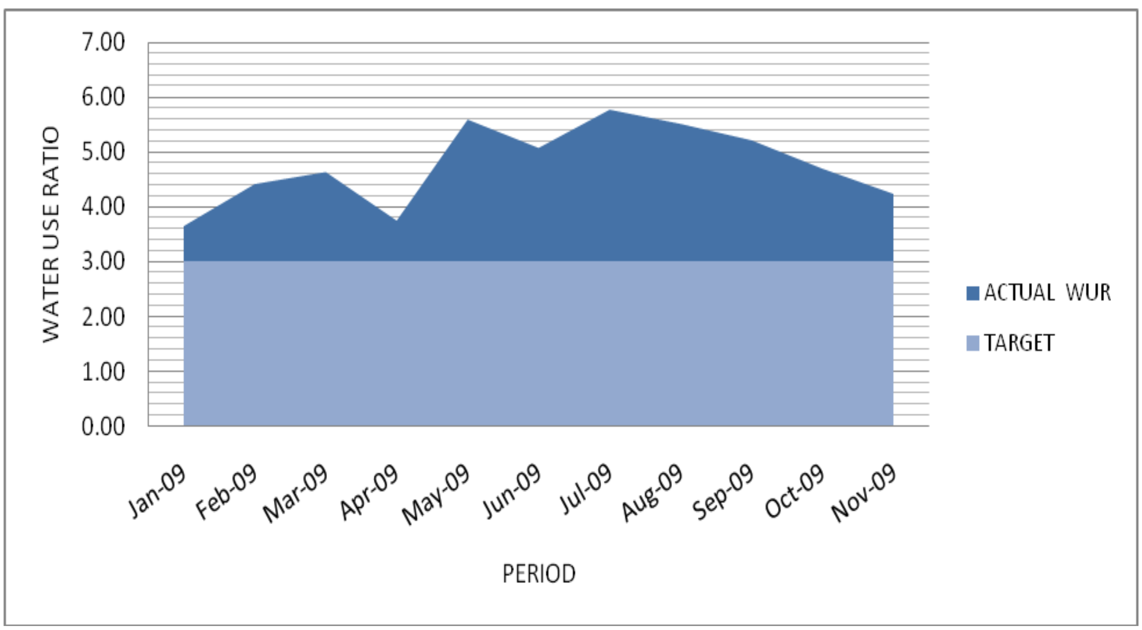


Figure 17 Trend in water usage before (Jan-May) and after (June- Nov) implementation of the source waste reduction measures

The water use ratio (WUR) basically represents the amount of water in liters used to prepare a one liter beverage. A high WUR ratio indicates that more water is being used to produce a liter of any beverage. This depletes water from the aquifer causing the water table level to decreases. The results in Figure 18 show that there was an increase in water usage from the month of January 2009 to July 2009, with the water use ratio (WUR) going up. During the month of July, the WR was at 5.78 the highest in year 2009. The waste reduction team came in with the activities highlighted above and key among them was replacement of the reverse osmosis membranes to increase the rate of recovery. A recovery of between 65% and 70% was targeted. This would be a recovery of more than 2 million litres of the 26.1 million litres of reverse osmosis reject. There was also the recovery of water from the conveyors and using the same water to clean the production floor.

The WUR reduction team was faced with many challenges that included lack of municipal water supply; hence all plant operations relied on the use of the treated water from the reverse osmosis system. This raises the water use ratio due to the reverse osmosis 40% reject. During the month of July the water use ratio reached 5.78. If the 5.78 water use ratio was maintained for the subsequent months (August, September, October and November 2009) the company would have lost 3.8 million liters of water as indicated in Table 18 (water used subtracted from the WUR at 5.78) . The 3.8 million litres saving still low as the set target of 3.0 WUR had not been achieved. Therefore, there is still a huge opportunity to save more water and if the target can be reached the company can save up to 23 million liters of water annually, see Table 18 (water used subtracted from WUR at 3.0).

Table 18 Comparison of water usage at various WUR versus actual

	AUG	**SEP**	**OCT**	**NOV**	**Total**
Water used	4,106,000	6,548,000	4,054,000	5,527,000	20,235,000
Total beverage	743,931	1,253,591	862,458	1,303,836	4,163,816
Actual WUR	5.52	5.22	4.70	4.24	
WUR at 5.78	4,299,921	7,245,756	4,985,007	7,536,172	24,066,856
WUR at 3.00	2,231,793	3,760,773	2,587,374	3,911,508	12,491,448

The savings can be realized by implementation of the proposed water reuse project and water harvesting in the plant. In monetary form the reversing of the trend from the month of July was a saving to the company of approximately half a million shillings. The potential on attaining the goal will be a savings of more than one million shillings. A huge potential then lies in this area and in 2010, the company management presented in the budget the reuse of process water.

The other method that the company could save financially on water is through water harvesting. After thorough analysis of the water use ratio with the management, rain water harvesting was also seen as a viable option to reduce the amount of money spent to get water from the borehole and the municipal supply.

The Current cost of water per Kilo Liter was submitted and was to be a summation of the Procurement Cost, (Annual water cess payment to government.) Pumping &

handling cost (Raw pump, RO pumps, distribution pumps etc), Chemical Treatment cost (All Chemicals used for treatment of water) and Disposal Cost of waste-water (Charges paid to MC for disposal of waste-water to POTW).

The average monthly rainfall data for the whole year was submitted to assess the possibility of having water throughout the year and also to help determine the capacity of the storage tanks required.

The tapping of all this water would reduce the cost of production and at the same time ensure that the company positively helps in creating a sustainable environment by abstracting less water from the well.

The company would spend less than one hundred thousand shillings to complete the project since most of the infrastructures needed like reservoirs are already in place, and at the same time realize a savings of more than half a million shilling spent on municipal supply monthly.

4.3.4 Carbon Dioxide

The financial impact of carbon dioxide came fourth with a potential savings of up to 1.5 million shillings. The carbon dioxide usage was audited as summarized in Table 19.

4.3.4.1 Carbon dioxide audit report

Table 19 Carbon dioxide audit report

SR. NO.	Location of Waste	Process	Description of Waste	Category of Waste	QTY PER YR	Quick -win (Y/N)
1	receiving bay	receiving	verification of what has being received	6	9,600	Y
2	warehousing	storage	exposure of the co_2 tank to heat	4	2,100	N
3	warehousing	transport ation	lots of leaks within the piping system	1	1,213	Y
4	filling hall	filling	condenser & vaporizer unit failure	1	45,500	Y
6	filling hall	filling	over carbonation	1	6,800	N
7	filling hall	filling	Non conforming product	1	23450	N
10	filling hall	filling	machine crashing	1		Y
TOTAL					88,663	

KEY: Category of waste.

1: Defect 2. Overproduction 3. Waiting 4. Not embracing change

5. Transportation 6. Inventory 7.Motion 8. Excess processing

The audit on the carbon dioxide process flow, reviewed losses from two sources. The first source was the carbon dioxide reservoir and the supporting utilities. This was due to leakages on the carbon dioxide filters and valves. The utilities failure to cool the carbon dioxide and have it remain in the liquid phase was generating a lot of pressure in the reservoir, causing the carbon dioxide gas to leak out from the safety valve. In total this section was losing more than fourteen tonnes of carbon dioxide Table 19. The second source of carbon dioxide loss was in the filling hall where the carbon dioxide filter and valves were leaking. The production of non-conforming carbonated products was also contributing to the losses as they could not be transferred to the finished goods warehouse for sale but were rejected and put to the drain. This filling process was losing more than seventy five tonnes of carbon dioxide annually.

Figure 18 shows a leaking safety valve due to pressure build up in the reservoir. Due to the low temperatures of liquid carbon dioxide some icing of water vapor occurs on the valve.

Figure 18 Leaking CO_2 safety valve

4.3.4.2 Carbon Dioxide Activities

To achieve a reduction in the carbon dioxide waste generated, the two areas of carbon dioxide losses had to be addressed.

The leakage at the reservoir had to be fixed by the Carbacid Company, who had leased it to BSK. The maintenance contract with Carbacid had to be reviewed and implemented.

At the filling station, the leaking pipes' joints, valves and filters had to be fixed. For the non-conforming products, regular maintenance of the blending unit and the filling unit was essential for the reduction of the same.

The operators were trained on process control and also on how to improve line utilization, as efficient runs use less carbon dioxide. The results of these activities are summarized in figure 19.

4.3.4.3 Carbon dioxide waste reduction activities results

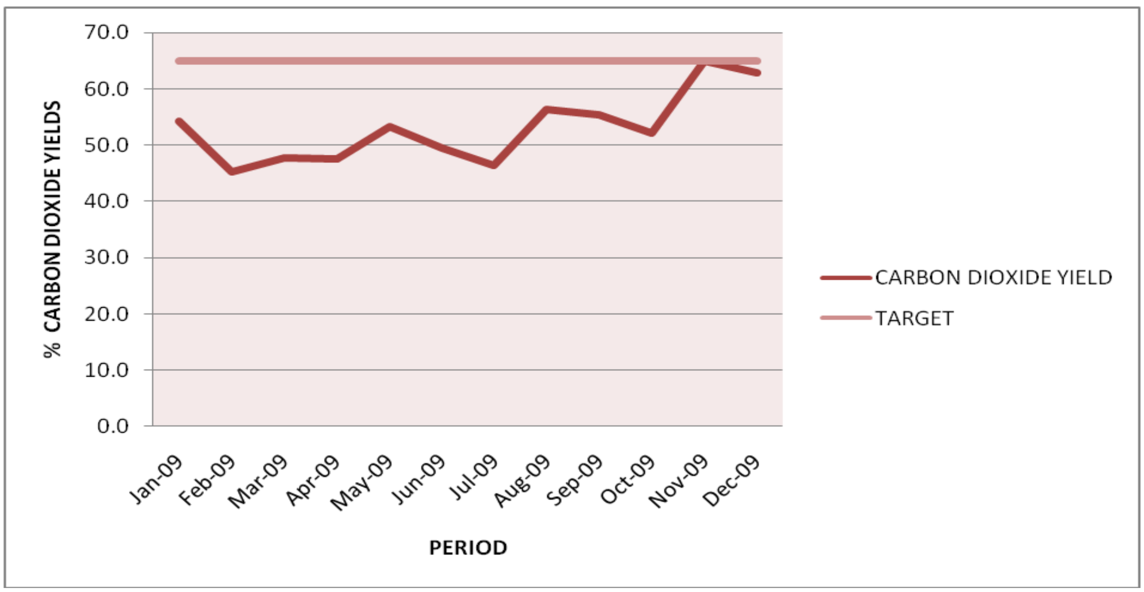


Figure 19 Trend of carbon dioxide yields before (Jan-May) and after (June- Nov) implementation of the source waste reduction measures

The carbon dioxide yield trend from the month of January indicates a lot of inconsistency on yields. This was largely contributed by the poor line utilization, resulting from breakdowns during normal carbonated beverages runs. The month of January to May had an average of 49.6%, then a drop for the month of June and July to

47.9%. August and September had an encouraging improvement to 55.9%. A team was assembled to help work on the issue, which yielded good results in the month of November and December at 63.7%. Generally the carbon dioxide yield trend improved though not as expected. More would have been realized were it not for the supplier's slow pace in fixing the issues highlighted on the carbon dioxide reservoir and the supporting utilities. The savings were calculated based on the months of February, March and April performance, which on average was at 46.8%. If the trend continued, the company would have lost a further 9.9 tonnes of carbon dioxide. At the end of the year, the slight improvements yielded the 9.9 tonnes savings for six months, and thus annual savings would be more than 19 tonnes ,which is equivalent to a savings of more than half a million shillings. There is a huge opportunity in this area and with the continuation of this project the target will be realized.

4.3.5 Packs

This was the sixth material on the priority list based on the financial impact to the company. The packs are the raw materials used to manufacture the package where Juice is packed. The packs are manufactured in Spain and hence the cost implication due to wastage during the production process is significant. They are specific to the Tetra line and flow of the material is similar to the preforms. The process starts from receiving of the materials from the supplier, storage in the raw material warehouse then issuing to the production department for processing. The audit report was tabulated in Table 20 in a similar format like for the preforms.

4.3.5.1 Packs audit report

Table 20 Packs audit report

SR. NO.	Location of Waste	Process	Description of Waste	Category of Waste	QTY Per Yr	Quick-win (Y/N)
1	Receiving bay	Receiving	verification of what has being received	6		Y
2	Warehousing	Storage	poor packs transportation	4		Y
3	Warehousing	transportation	poor packs storage	4	5,445	Y
4	Filling hall	Filling	during the programming phase- tube sealing	6		N
5	Filling hall	Filling	left jaw electrical cable fault- paper waste	1		Y
6	Filling hall	Filling	left jaw electrical cable fault- product waste	1		Y
7	Filling hall	Filling	right jaw electrical cable fault- paper waste	1	16,543	Y
8	Filling hall	Filling	right jaw electrical cable fault- product waste	1		Y
9	Filling hall	Filling	DE stoppage filler stops generating paper waste	1		Y
10	Filling hall	Filling	DE stoppage filler stops generating product waste	1	27,654	Y
11	Filling hall	Filling	packs overfilling	1		Y

KEY: Category of waste.

1: Defect 2. Overproduction 3. Waiting 4. Not embracing change

5. Transportation 6. Inventory 7.Motion 8. Excess processing

Table 20: Packs audit report continued,

SR. NO.	Location of Waste	Process	Description of Waste	Category of Waste	QTY Per Yr	Quick -win (Y/N)
12	filling hall	Filling	packs under filling	1		Y
13	filling hall	Filling	product in wrong paper package	1	2,040	Y
14	filling hall	Filling	pack not well formed- flap generate paper waste	1	2,380	Y
15	filling hall	Filling	timing belt failure- product crushing at the filling unit	1	3,900	Y
16	filling hall	Filling	product mishandling on the conveyors	1	4,850	Y
17	filling hall	Filling	poor date coding	1	1,200	Y
18	packing hall	Transportation	packs congestion on the conveyor- deform packs- generate waste	1	3,450	Y
19	packing hall	Capper	cap application not aligned - lose pack and product	1	3,470	Y
20	packing hall	Planning	expired product in the warehouse	2	1,825	Y
TOTAL					74,901	

KEY: Category of waste.

1: Defect 2. Overproduction 3. Waiting 4. Not embracing change

5. Transportation 6. Inventory 7.Motion 8. Excess processing

In this section, pack wastage was hugely due to defects, yielding more than sixty seven thousand packs, a 90% contribution during the processing followed by the company's failure to embrace change.

In the filling hall, more than forty thousand packs were being lost during production runs. This was largely due to the filling machine stoppages after mechanical breakdowns. In particular, a jaw problem was recurring, and it required the company to purchase a new set of jaws. The jaws are the cutting parts of the machine that cut the continuous reel into distinct packs. Mishandling of the packs on the conveyor was also contributing to the losses and for this reason; awareness training was carried out to sensitize all the operators on the issue.

The warehouse had more than five thousand packs annually being lost due to poor handling of the paper. Use of pallets with rough edges introduced dents on the paper reel leading to rejection. Poor storage of the paper that includes failure to cover production remnants led to rejection of the reel due to dust accumulation on them.

The line being a state of the art has a capability to deliver zero waste. The utilities supporting the line played a key role in the generation of this waste due to frequent stoppages of the filling unit.

Overproduction on the same line contributed to packs wastage as one third of the small packs expired in the warehouse due to the provision of inaccurate forecast numbers by the marketing team.

Some of the waste generating areas are shown in Fig. 20 with a polythene bag on the side with rejected packs from the filling unit.

Figure 20 Tetra packs filler losses

At this station the packs put on a polythene paper are startup losses if the previous product was different, the date code was not set properly, and the filling equipment did not accept the filling command immediately with an area that is wanting or if the pack formation unit was not well aligned hence products crushing at the exit.

4.3.5.2 Packs Waste reduction activities

Some of the activities carried out to eliminate pack wastes included a detailed training for the warehouse and operational personnel on waste minimization. The training covered good warehousing practices that included proper transportation of the packs to prevent damage and their proper storage that included covering the packs to prevent dust accumulation.

Maintenance of all the tetra line equipments to improve process efficiencies was key and involved generation of maintenance schedules and the spare parts requirement list. The operators were sensitized on process control through a continuous process monitoring program that required checking the pack integrity during the filling process and taking a corrective action in case of a deviation from the set standards.

Sales' forecast numbers were also reviewed for accuracy to prevent over production leading to product expiring in the warehouses. The results of the implementation of the above are summarized in Fig 21.

4.3.5.3 Packs waste reduction activities results

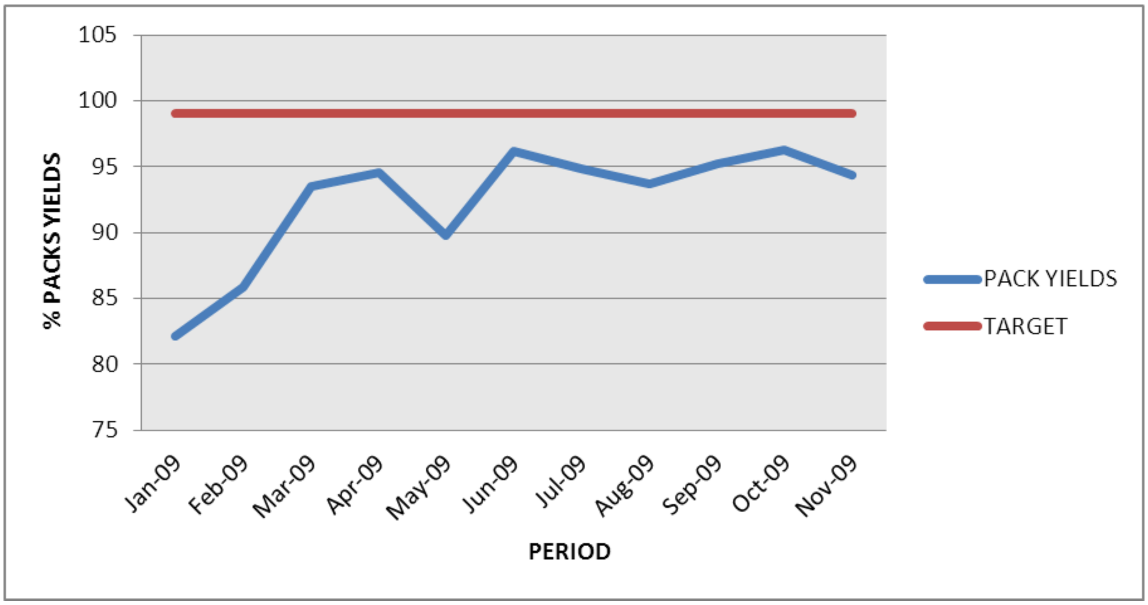


Figure 21 Trend of packs yields before (Jan-May) and after (June- Nov) implementation of the source waste reduction measures

The packs yield from the month of January to May was at an average of 89.2% but the project realized a positive shift from the month of June to November to yield 95.1%. This was a 5.5% positive shift equivalent to a savings of 175,352 packs which translates to 2.3 million shillings savings for only six months Table 21.

Table 21 Packs usage comparison before and after the waste reduction program

	Actual	Target	% Yield
Total packs used Jan to May	708,837	633,936	89.4%
Total packs used June to Nov.	1,525,864	1,448,280	94.9%

This can be attributed to the tetra filler and downstream equipment efficient runs demonstrated by the line utilization that also had a positive shift from 39% to 58%. There is room for improvement in this area as the target has not been achieved yet. This will include an investment of close to twenty million shillings for the purchase of a higher capacity cooling system to achieve long runs. The management put up a proposal under capital expenditure to purchase a chilling unit by the end of year 2010.

4.3.6 Source waste reduction summary

Table 22 Source waste reduction summary

	Preforms %	Strategic ingredient's %	Carbon dioxide %	Water (WUR)	Packs %
Yields Before	97.3	97.0	46.8	5.78	89.18
Yields After	98.3	97.2	63.7	4.24	95.24

Table 23 ANOVA

Source of Variation	*SS*	*Df*	*MS*	*F*	*P-value*	*F crit*
Rows	51.16	1	51.17	1.83	0.25	7.71
Columns	12880.83	4	3220.21	115.31	0.00022	6.39
Error	111.71	4	27.94			
Total	13043.7	9				

Table 22 above gives a summary of the source waste reduction exercise result before and after the implementation of the project. The yields after the project implementation improved significantly across all the raw materials thus supporting the alternative hypothesis where it is possible to have a source waste reduction in a plant. The calculated F value in table 23 is greater than F critical thus not within the critical limits therefore the two tables rejecting the null hypothesis that stated that it is not possible to have source waste reduction in a plant.

4.3.7 Offsite Waste treatment Reduction

The implementation of the offsite waste reduction measures on the all material inputs in Table 10 and implementation of the obvious waste reduction measures on all the six materials in Table 11 brought a considerable shift in the volume of waste treated outside the plant as shown in the Fig 22. As the waste reduction measures were being implemented, a substantial waste reduction in treated waste outside the plant was observed, (Fig 22), the exception of the month of July and September where an increase in waste was observed. This was due to an increase in production volume in July with 1.03 million litres and September with 1.3 million litres compared with august with seven hundred and forty thousand million litres. This was an indicator that waste reduction at the source was practical and real.

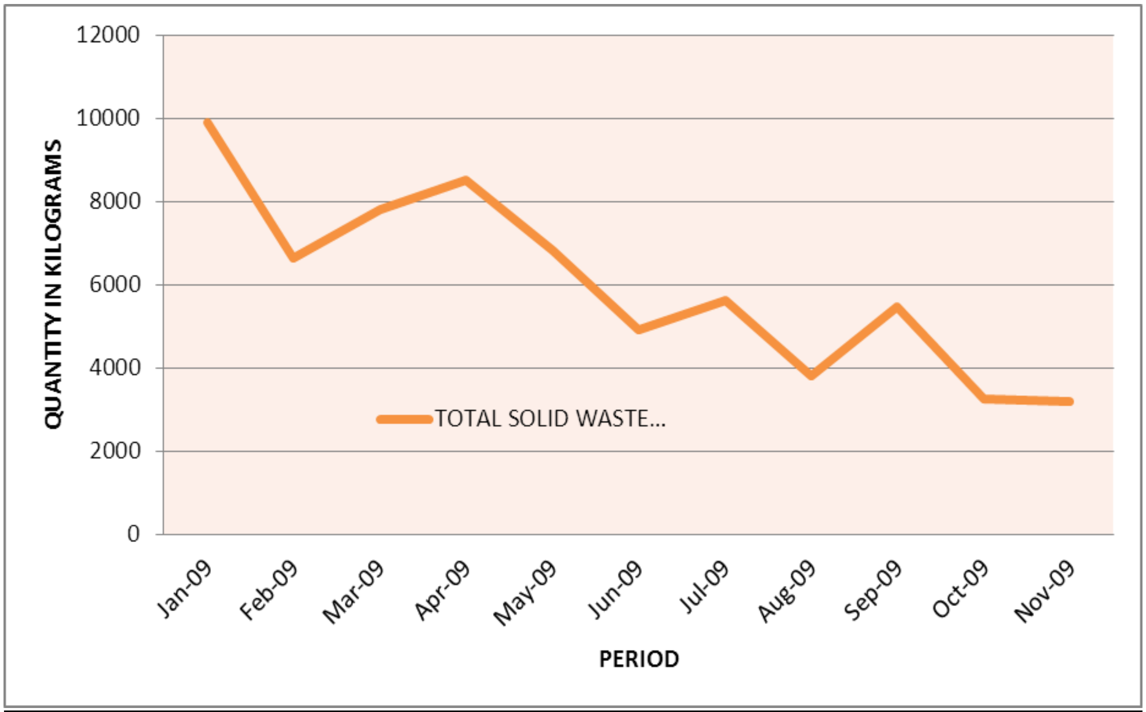


Figure 22 Offsite waste treatment volume trend before (Jan-May) and after (June- Nov) implementation of the source waste reduction measures

This was achieved through the implementation of obvious waste reduction measures like pallet repair (Figure 23). More waste reduction of offsite treated waste can be attained by implementing long term measures that include reorganizing the warehouse. For instance the introduction of metal cage system in the warehouse can ensure a significant reduction in the pallets used and the current pallet stretch wrapping polythene replaced by a wire mesh. A cage is stronger than a pallet hence a reduction in products damaged during transportation within the warehouse generating waste. Appendix 2 is a proposal to have the cage system in the BSK warehouse.

Figure 23 Repaired pallets

A Change in packaging style Figure 24 and 25 encouraged the use of recyclable containers. The preform suppliers were requested to pack preforms in returnable cartons (Figure 25), instead of the poly-bags (Figure 24) that could not be recycled. This reduced the offsite waste by 8%.

Figure 24 Packed preforms in bags

Figure 25 Packed preforms in returnable cartons

4.4 Step 11: Sorting of Waste at BSK

To have a viable offsite waste treatment reduction exercise the project had to come up with a way that could prevent mixing of the generated waste. The mixing could lead to deterioration of the waste necessitating its dumping into an open dump. The method of sorting and keeping the waste separately was found to be the best. This enhanced opportunities for recycling and reuse with a resultant savings on materials cost. It also helped in pollution reduction that can occur through cross contamination of waste materials. To enhance this activity the following areas were marked and segregated to hold the different waste produced within the plant before recycling, reuse or disposal. A solid waste accumulation area Fig 26, Papers and cartons section Fig. 27, Plastics containers section Fig.28, Preforms rejected from the system section Fig. 29, Pallets and rejected woods section Fig 30 and 31, Scrap metals and small plastic machine components section Fig.32 and a drum container for used oil storage before disposal Fig. 33.

Figure 27 SW accumulation area

Figure 26 Paper & carton area

Figure 28 plastics section

Figure 29 preforms section

Figure 31 wood section

Figure 30 Broken pallets section

Figure 32 Scrap metal section

Figure 33 Used oil section

4.5 Step 12: Developing Long Term Waste Reduction Option

The result of the waste audit and waste reduction studies were formally presented to the company management in the form of an audit report with the activities that could be carried out as collective actions. The recommendations made were accepted and plans were made to implement them. This included a budgetary allocation for the year 2010.

The waste audit had provided a sound understanding of all principle sources of waste arising from the entire process. Furthermore, the process technicians assigned to assist in the waste audit became aware of the great role they can play in helping the company make savings on raw material and the knowledge gained could be applied in other areas.

It was considered that the experience gained by the technicians on the few raw materials considered in this project would enable the entire company staffs take a lead in any future waste minimization programme. That includes waste audits during the monitoring phase, commissioning of new processes and other plant modifications and additional proposals.

From the current study one can say that a meaningful reduction of waste at the source can be attained by implementing obvious waste reduction options but better results can be obtained by encompassing long term plans on waste reduction. The long term options help an organization to have a vision of where it wants to position itself in waste management.

The long term goals help in planning, especially in resource allocation necessary to have result oriented programs. Therefore this project came up with a list of activities that were presented to the management as proposals for their implementation in the year 2010. Three proposals were generated and include,

1. Waste water reduction that involves reuse of process water (appendix 1)
2. The use of metal cages to hold product within the warehouse instead of palletizing and stretch wrapping. (appendix 2)

4.6 Step 13: Environmental and Economic Evaluation of Waste Reduction

The process of reducing waste in this project started with the audit preparation followed by building of a material balance from the inputs and outputs of the various distinct processes. The material balance was then used to highlight areas generating the highest waste and those areas prioritized for a waste reduction program. The implementation of the waste reduction program gave some results with both economic and environmental benefits.

Environmental gains include first the use of fewer raw materials due to increased process efficiencies thus preserving some for future generation. Second, the processing of raw materials require the use of energy to convert them to final product, the more materials processed the more energy is used. Reduced material usage due to increased process efficiency thus has a direct impact on reduction of energy used in the form of electricity either from fuel or hydro power. All these are natural resources and when well preserve it's an environmental gain. Thirdly the increased process efficiency, reduction of raw materials used and reduction in energy use results in less pollution in the air, water or soil.

Economic gains the company realized after the implementation of this project is summarized in the Table 24.

Table 24 Economic gain on the selected raw materials

Raw material	yield improvement ratio	The monetary value of the improvement (kshs)
Preforms	+0.6%	900,000.00
Sugar	+0.25%	100,000.00
Concentrates	+3.7%	500,000.00
Carbon dioxide	+14.1%	500,000.00
Water	3.8 million liters	700,000.00
Packs	+5.5%	5,000,000.00
Waste disposal cost	Trips paid reduction by 60%	50,000.00

The general waste reduction by more than 60% was also an indicator that the company was achieving process efficiency leading to a better conversion of raw materials to sellable products. This was demonstrated by the gains made on the preforms, strategic ingredients, packs, sugar, and water as summarized in Table 24 above.

The annual saving on the preforms, totaling over nine hundred thousand shillings indicated that the company was not purchasing more than a hundred thousand preforms that would have been lost during the production process hence a savings to the company and also no stress to the natural resources as petroleum is the main material used in the manufacture of resins that make preforms and blown to make bottles is reduced Table 15.

The savings realized on paper of close to five million Kenya shillings which was another demonstration of how waste reduction can be a savings to the company (Table 22). This money can be invested in other areas ensuring continuity and growth of the company. The manufacture of paper is a stress to the environment as more trees are used to ensure paper is available in the market. During the paper manufacturing process air, soil and water pollution takes place thus a reduction in paper production reduces these negative environmental effects.

The annual savings on carbon dioxide was approximately nineteen tonnes equivalent to more the half a million shillings Fig 20.The cost of purchase, storage and manpower would also introduce a negative effect on the company performance.

There was some savings on Sugar and Strategic ingredients which are largely extracted from plants (Table 16). A savings implies that no stress to the natural resources. The cost of production, transportation, storage and handling since they are in bulk is saved.

On water reversing the trend from the month of July had a savings of 3.8 million liters Table 19. This is enough water to run the plant for one month. A savings of twenty two million liters is enough water to run the plant for 5 months (Table 19). These are huge savings and all geared towards sustainable development where the future generation will be guaranteed to have enough water. Economically the company saves as no payments will be paid for these volumes. The treatment, storage and handling cost will not be realized.

The results summarized in table 24 was achieved with minimal financial interventions thus a proof that a waste reduction exercise in a plant is economically viable.

4.6.1 Waste reduction program

The above environmental and economic gains were realized through the implementation of a logical waste reduction program that involved

1. Identification of the process or area of concern.
2. Dividing the process into simpler units of operation
3. Carrying out a waste audit in these units of operation to identify the source of waste, the type and quantity involved.
4. Identifying the reason why there is generation of waste in this area
5. Raising a corrective action plan
6. Implementing the corrective action plan and
7. Finally checking the effectiveness of the corrective action plan.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The purpose of this project was to establish a waste reduction management system at Beverage Services Kenya limited. The objective was realized on the six items selected with a positive gain to the company in monetary form and also ensuring that all operation were aligned to its policy of carrying out operations in an environmentally friendly way. The project also demonstrated the potential economic and environmental benefits of a waste reduction program. To accomplish this goal, a waste audit was carried out defining source, type and quantity of waste generated. To have an easier approach to the audit the entire process was divided into six units of operations each with a comparison of material input and output. During the audit the process inefficiencies were highlighted and addressed to realize the project objective hence completing the waste reduction program. By demonstrating the benefits of a program on waste reduction at the source in a "micro level" case study, such as the one put forth in this project report, the "macro level" theory is supported. The "macro level" theory been that source waste reduction programs are possible in a large scale level and are both environmentally and economically beneficial both to the manufacturer and the nation. As a nation waste management can become easy if all the companies and homesteads in the country can adopt a waste minimization initiative. Irrespective of the location of the waste, any company can realize an economic gain by utilizing proper waste minimization techniques. By using materials more efficiently, industries can reduce the generation of waste and achieve the desirable protection of human health and the environment, (Lawrence *et al*., 2004). At the same time the costs of waste management and regulatory compliance can be lowered and long term liabilities and risks can be minimized.

All these gains were made with an overall offsite treated waste volume reducing by more than 60%. The project demonstrated the economic benefits of source waste reduction program and environmental benefits were also highlighted. The project proved that the popular misconception i.e. "a policy that is good for the environment is bad for the economy." is not true and the two cannot be separated. As demonstrated in this project, source waste reduction is both good for the environment and good for the economy. Source waste reduction is one environmental policy that debunks conventional wisdom surrounding the environmental movement (Louis and Young, 1992).

If more businesses were aware of this fact, there would be less apprehension when it comes to the implementation of an environmental policy. It is clear from the current study that source waste reduction programs are an important aspect in improving the environmental and economic state of the nation and the world at large. If more companies were to implement effective source waste reduction programs, not only the environmental benefits, but also the economic benefits to the companies would be substantial.

5.2 Recommendations

At the national level the project strongly recommends amendment to the Environmental Management and Coordination Act (EMCA) of 1999 to introduce a clause on waste minimization at the source. Also the National Environment Management Authority should have a similar clause in its mandate on waste management.

The project also recommends further study in the area of reverse osmosis waste water a technology most industries are installing to treat water for manufacturing purposes. The use of a better water treatment technology with less waste generation should always be a significant factor considered during the design process of these systems (Wesley's *et al.*, 2009).

The country needs also to embark on training its citizens on waste minimization especially at the source.

In this project only six process inputs were considered and therefore recommend to the company management, the extension of this waste reduction approach to the other raw materials. This includes capital investment for both short term and long term waste reduction activities. A source waste reduction policy formulation is necessary followed by dedication of period during which the organization is to create awareness across all functions.

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APPENDICES

Appendix 1 A Proposal to Reuse Process Waste Water

In step 5 on water usage determination Table 3 outlined the water usage in five sections, three lines and the two warehouses. In some processes the water used can be recycled as per the analysis done and tabulated in Table 25 on process water analysis. The rinser in Table 3 generates over seven hundred litres of waste water monthly whose chemical and physical parameters are well within specifications as per Table 25. Similarly line 1 and 2 clean in place water can be recovered from the rinsing and cooling process. This amounts to more than two hundred thousand litres of water. If the nine hundred thousand litres of water can be recovered as per Figure 34 (process water recovery layout) on monthly basis then the company will not need the municipal water supply.

To achieve this goal all the required materials were listed (Table 26: Process water Materials Requirement) and quotations requested from different suppliers and on estimate the company will only invest two hundred thousand shillings only.

Table 25 The Process Water Quality Analysis

Parameter	**Units**	**Treated Water**	**Filler Rinse Water**	**KHS And Tetra Cleaning Process Rinse Water**	**Recommended Kenya Standards (KS 05-459; Part 1: 1996)**
pH	pH Units	8.23	7.88	8.43	6.5 - 8.5
Turbidity	NTU	0.29	0.35	0.45	< 5.0
Colour	Pt. Co. APHA	ND	ND	ND	15 TCU
TDS @ 25 oC	Mg/L	5	12	25.3	1500 Max.
Conductivity @ 25 °C	MicroSiemen/cm	10.9	24.9	50.6	NS
Total Alkalinity	Mg/L $CaCO_3$	1	23	21	NS
Phenolphthalein Alkalinity	Mg/L $CaCO_3$	ND	ND	8.1	NS
Total Hardness	Mg/L $CaCO_3$	< 1.0	< 1.0	< 1.0	500
Calcium Hardness	Mg/L $CaCO_3$	0.12	0.17	0.33	NS
Magnesium Hardness	Mg/l $CaC0_3$	0.05	0.07	0.25	NS
Calcium	Mg/l Ca	0.05	0.09	0.15	250
Magnesium	Mg/l Mg	0.01	0.01	0.21	100
Manganese	Mg/l Mn	ND	ND	ND	0.1
Potassium	Mg/l K	ND	ND	ND	50
Chloride	Mg/l Cl-	< 1.0	< 1.0	< 1.0	250
Fluoride	Mg/l F	0.02	0.5	0.16	1.5
Iron	Mg/l Fe	0.01	0.03	0.03	0.3
Sulfate	Mg/l SO_4	ND	0.03	ND	400
Nitrate	Mg/L NO_3	0.1	ND	0.12	10
Nitrite	Mg/l NO_2	0.004	0.2	0.006	NS
Silica	Mg/l SiO_2	3.7	0.005	4.1	NS
TSS	Mg/l	ND	3.4	35	NIL

Key: NS- Not specified ND- not done

FIGURE 34: A DRAWING OF PROCESS WATER RECOVERY

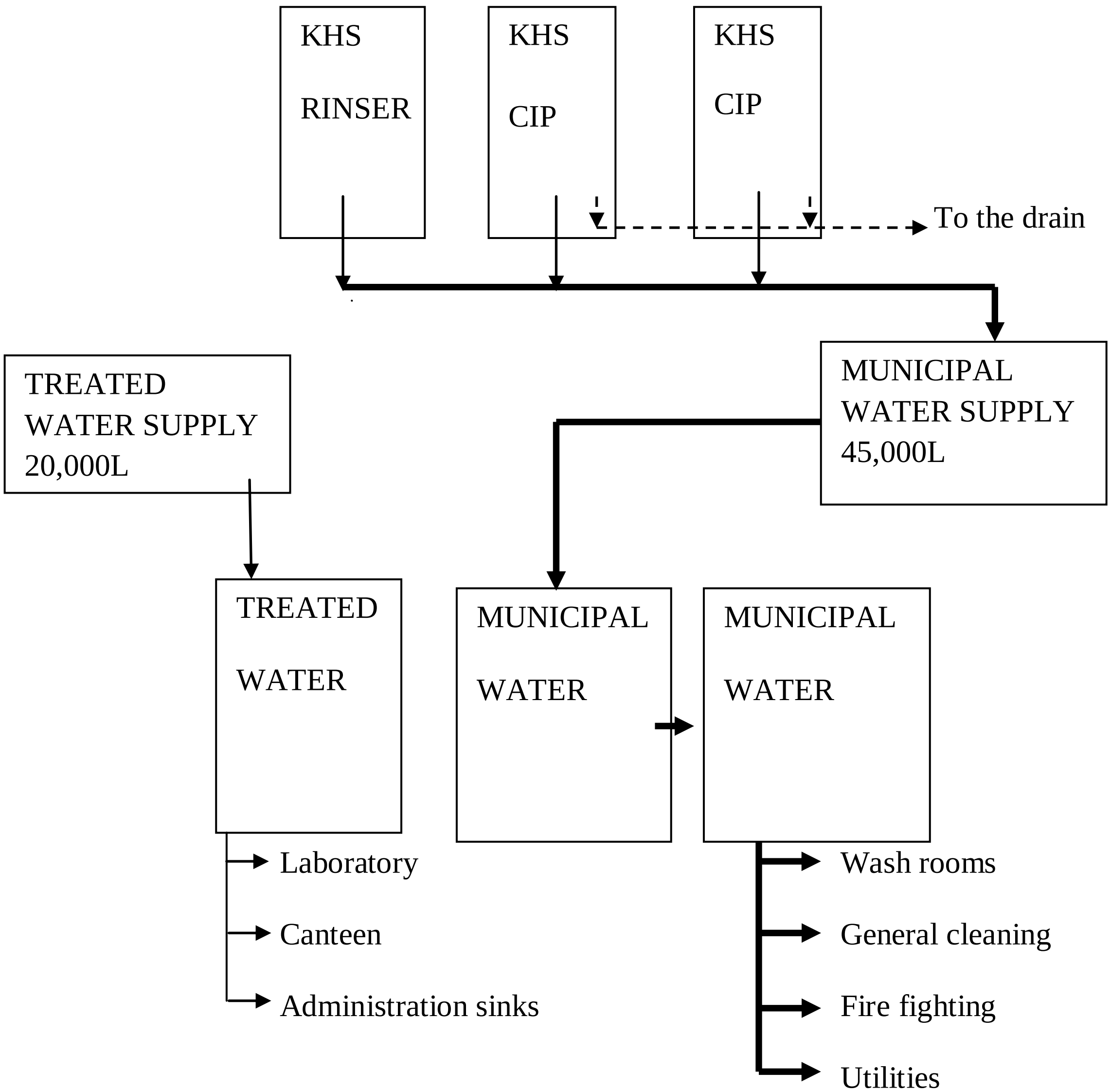

Figure 34 Process Water Recovery Layout

Table 26 Process Water Materials Requirement

Sr. No	Material	Specifications	Quantity
Filler Rinse Water			
1	Submersible Pump	0.75kw	1 Pc
2	Plastic Container	High Density	$0.5M^3$
3	Stainless Steel Pipes	38mm -316	2pcs
4	Galvanized Pipes	38mm	3 Pcs
5	Galvanized Elbows	38mm	3pcs
Line 1(KHS) and Line 2 CIP Returns			
6	S Steel Butter Fry Valve	50mm	3
7	Stainless Steel Pipes	50mm	4 Pcs
8	Stainless Steel Reducing Bush	50mm To 38mm	2
9	Stainless Steel Elbows	50mm	4
10	Galvanized Pipes (Class B)	38mm	14
11	Galvanized Elbows	38mm	3
12	Stainless steel reducing bush	50- 20mm	1
13	(3/4) galvanized pipes (class B)	20mm	5
14	20mm galvanized elbows	20mm	5
Laboratory Water			
15	(3/4) Gate Valve	20mm	2 Pc
16	Galvanized Pipe Class B	½ Inch	3
17	Gate Valve Pegler	¾ Inch	1pc
18	Gate Valve Pegler	½ Inch	3 Pcs
19	Inch Reducing Bush	¾ To ½	2pcs
20	Tee Joints	½ Inch	3 Pcs
21	Elbows	½ Inch	10pcs
22	Nipples	½ Inch	10pcs
23	Sockets	½ Inch	10pcs
24	Flexible Pipes		100m

After the above materials were specified the next step was to go through the procurement procedure that involves getting three competitive quotes for the materials from different supplies.

This was done and together with labor the estimated cost of the project put at 200,000/=.

Due to cash flow issues the entire project was allocated funds in the year 2010.

Appendix 2 A Proposal on Cage System in the Warehouse

To reduce on the use of polythene paper of very low micron we worked together with the warehousing team that was engaged in the waste reduction process and made a proposal to have a cage system in the warehouse. In this proposal we recommended that the warehouse be provided with standard cages with a capacity to hold a specified quantity of product from the line. The cage is mobile and hence easy to carry with a forklift from the palletizing area to the warehouse and at the same time have the allowance to be stuck three high in the warehouse. This proposal is to realize the advantage of products in the warehouse taking less space, reduce the use of pallets hence reduce warehousing cost and remove the use of stretch wrap at the palletizing stage. This will be a capital expenditure planned for implementation in the year 2010 as communicated by the company management.

Appendix 3 Water Use Pictorial Communication

<u>THE WATER EQUATION</u>

Water demand = water content in product + process waste water

The plant should aim at reduction of process waste water.

Figure 35 Water Equation

Figure 36 Four R's Repair, Reduce, Recycle and Re-Use

Figure 37 Water Wastage