Cleaner Production Framework for an Beverage Manufacturing Company

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***Abstract*—**This study explores to improve the resource efficiency, waste water reduction and to reduce losses of raw materials in a beverage making industry. A number of cleaner production technologies were put across in this work. It was also noted that cleaner production technology practices are not only desirable from the environmental point of view, but they also make good economic sense, in their contribution to the bottom line by conserving resources like energy, raw materials and manpower, improving yield as well as reducing treatment/disposal costs. This work is a resource in promoting adoption and implementation of CP in other industries for sustainable development.

***Keywords*—** resource efficiency, beverages, reduce losses, cleaner production, energy, yield

I. Introduction

CLEANER PRODUCTION (CP) is a set of initiatives to protect the environment by minimizing waste and emissions and maximize product output by analysis of materials and energy [1]. It is a continuous application of an integrated, preventative environmental strategy towards processes, products and services in order to increase overall efficiency and reduce damage and risk to humans and environment.

If CP is adopted it helps to [2]:

- reduce and minimize the harm caused by waste
- improve safety of the workers
- reduce cost incurred in waste treatment and disposal hence reducing the cost the amount of fine paid to the municipal authority due to harmful waste
- create a good image of the company at the same time it benefits both the environment and business.

II. Justification

Significant efforts by beverage manufacturers to implement greener manufacturing strategies have been observed, however some areas still require a greater attention as end of pipe solutions are being practiced. Pollution remains an area of major concern. The forms of pollution include: noise, water, thermal and land pollution from various manufacturing operations.

Waste in the form of acidic water containing solid is directed into the water-drain which is major threat to the surrounding land and ecosystem. Currently other companies are contracted for the collection and disposal of solid waste. After an audit at the case study site, cardboard, plastic containers and closers (bottle tops); labels and glue could be recycled together with electronic waste.

Water usage is estimated to be 2, 5 to 3,5 liters of water per liter of products hence there is need for cleaner production implementation. With the current rise in the global population and the change in the climatic weather the demand for water is increasing .Hence the need to provide an alternative way of minimizing water consumption [3]. The current practice has been the use of end of pipe solution where acidic waste water is treated with Sulphur dioxide.

Electricity, being the major source of power, during power cuts the firm has resorted to the use of diesel powered generators which has intensively contributed to the high levels of noise in the plant. The combination of the noise produced by the generator and the packaging machinery exceed the 80dB (A) level. Exposure to this high level to noise at work can cause irreversible hearing damage and is difficult to detect as the effects would gradually increase over time. The boiler, forty bar compressor and the shrink wrapper being the major consumers of energy in the production line. No monitoring has been done to take into account the amount of money that could be saved by an efficient management of this equipment hence the need for a cleaner production approach in this type of manufacturing set up.

III. Cleaner Production Overview

Not caring for the wastes can work, when the quantity of wastes are small compared to the sink where they are disposed off and provided the waste can be biologically degraded within a reasonable time period. This situation remains true today only for very small remote communities who are also not large consumers of non- biodegradable or toxic products [4]. However, as chemicals and industrial products have become more complex, less biodegradable, larger in volume and the wastes more dangerous and persistent, the old strategy of "out of sight-out of mind," stopped working well [6]. Problems of global warming, ozone depletion, soil depletion, toxic contamination of soils and water resources, loss of habitat and biological diversity all require a change of production techniques, a reduction in materials and energy throughputs, more efficient production, changes in the final products and also in the consumption ethic [1]. All of these concepts are embedded in the newer approach of cleaner production, pollution prevention and industrial ecology.

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Cleaner production technologies provide a more fundamental and basic approach to dealing with environmental degradation from economic activities. Clean technologies also provide developing countries with the additional possibilities of "leap-froging" over the older, more polluting, growth path followed historically by the more industrialized countries [5].

Cleaner production is defined as continuous application of an integrated preventative environmental strategy to processes, products and services to increase eco-efficiency and to reduce risk to humans and the environment [2]. It succeeds the pollution dispersion, control and recycling strategies by preventing or minimizing the creation of waste and pollutants. And it precedes the sustainable development strategy which emerged as an environmental management strategy but can no longer be regarded as strictly environmental given its focus on integrating rather than balancing objectives regarding economical growth, social equity and environmental protection and resource conservation example.

A. Cleaner production and polluting control [4]

Fundamentally cleaner production seeks to make the company more efficient and less polluting .The goal being to avoid pollution by using resources and raw materials are turned into valuable products instead of being wasted. Many cleaner production improvements require little or no initial investment or have a rapid pay back. It is a preventive business strategy designed to conserve resources, mitigate risks to humans and the environment, and promote greater overall efficiency through improved production techniques and technologies. Cleaner production methods may include:

- substituting different materials
- modifying processes
- upgrading equipment
- redesigning products

A carefully implemented cleaner production results in reduced long-term liabilities which companies can face many years after pollution has been generated or disposed at a given site and it usually increases profitability, lowers production cost, enhances productivity, provides a rapid return on any capital or operating investments require increases product yield, leads to the more efficient use of energy and raw materials.

B. Cleaner production and quality and safety [5]

Safety and quality are very important aspects of the food industry. While food safety has always been an important concern for the industry, it has received even greater attention over the past decade due to larger scales of production, more automated production processes and more stringent consumer expectations. A stronger emphasis is also being placed on quality due to the need for companies to be more efficient in an increasingly competitive industry.

In relation to food safety, Hazard Analysis Critical Control Point (HACCP) has become a widely use tool for managing food safety throughout the world. It is an approach based on preventing microbiological, chemical and physical hazards in food production processes by anticipating and preventing problems, rather than relying on inspection of the finished product [8].

Cleaner Production should operate in partnership with quality and safety systems and should never be allowed to compromise them. As well, quality, safety and Cleaner Production systems can work synergistically to identify areas for improvement in all three areas [3].

B. Cleaner production in practice

Without the mandatory requirement for companies to carry out toxic use reduction plans, and without the stimulus of public access to information about a company’s hazardous emissions as well as legislation that makes wastes and hazardous emissions too costly to ignore, factories will continue to pollute.

Companies can achieve clean production by [6]:

-Knowing all the chemicals used, and in what quantities, in their production system by doing a comprehensive materials audit

-Assessing the hazard of each chemical and material, and ensuring that the information on all releases of hazardous substances are publicly available for free

-Prioritizing all hazardous chemicals for elimination, through substitution with safer chemicals in processes or through product redesign

-Establishing reduction targets and timelines for complete elimination of current hazardous chemicals use through toxic use reduction and elimination plans

Cleaner productions in relation to beverage manufacturing will emphasize greatly on the following:

-Use of materials

-Energy consumption

-Minimization of waste

-Minimization of emissions

-Reduced risk to humans

i. Use of materials and resources

High consumption of good-quality water is characteristic of beverage manufacture [10]. Large quantities of good-quality water are needed for drinks. More than 90 percent of drink is water and an efficient process of beverage production will use between 4–7 liters (l) of water to produce one liter of drink In addition to water for the product, beverage manufactures use water for heating and cooling, cleaning packaging vessels, production machinery and process areas, cleaning vehicles, and sanitation. Drink manufacture requires water in almost every stage of production, but certain production methods or machinery can lead to overuse. If well or pump water is used, excessive water use can deplete water sources for future production or community use. With an increasing population it is important that inefficient equipment and consumer behavior do not waste this valuable resource [12]. Reducing water consumption will not only reduce the purchase cost of water, it also reduces the heating cost and the waste water discharge.

ii. Minimization of waste

Beverage manufacture generates large amounts of waste. Waste in the form of solid waste, acidic water, cardboard, plastic containers and closers (bottle tops); labels and glue. Many of these wastes contain valuable materials that can be reclaimed and re-used, reducing the need to exploit new supplies of a resource. Sewage water and waste water from the cleaning processes of the floors, tanks and bottles has an acidic pH hence it under goes pH level monitoring before being discharged. Depending on the dilution available there may be significant increase in the in the dissolved and solid organic content, nutrients color and turbidity and these may give rise to undesirable changes in water quality particularly as downstream abstraction [12].

Techniques for treating industrial process wastewater in this sector include flow and load equalization, pH correction; sedimentation for suspended solids reduction using clarifiers; and biological treatment. Biological nutrient removal for reduction in nitrogen and phosphorus and disinfection by chlorination are sometimes required. Dewatering and disposal of residuals; in some instances composting or land application of wastewater treatment residuals of acceptable quality may be possible. Additional engineering controls may be required to contain and neutralize nuisance odors. Adoption of anaerobic biological treatment, followed by aeration is increasingly adopted by breweries worldwide. This technique has the benefits of much reduced footprint, substantial electricity savings and generation of biogas which can be used in boilers.

iii. Reduced risk to humans

Food and drink production results in hazardous working conditions, excessive heat caused by operating machines such as the Shrink Wrapper and the blow molder, lack of ventilation, skin irritants can cause damage to the workers. Certain working conditions such as exposure to chemicals in the air or in solution baths during the cleaning of tanks can be hazardous to workers. Beverage manufactures often have large refrigeration systems, typically using ammonia refrigerant which is toxic and can form explosive mixtures in air. Symptoms can include skin irritations, dizziness and breathing problems. An unhealthy workforce can lower productivity, cause excessive absences and contribute to potentially costly mistakes. Physical hazards include exposure to same-level fall hazards due to slippery conditions, the use of machines and tools, the handling of glass bottles, and collisions with internal transport equipment, such as forklift trucks. Mills, mixers, grinders, augers and conveyors are potential hazards and may catch fingers, hair, and clothing. Eye injuries are a particular risk prevalent in bottling operations. Beverage manufacture activities that may expose workers to risk of injury typically arise from heavy manual lifting and carrying (for example, crates of bottles); repetitive work including packing and cleaning, and poor work postures caused by inadequate workstation and process activity design. When products and packaging are designed, their influences on mankind and natural environments during their life-cycle must be considered and priority accorded to selecting toxin-free, non-hazardous, easily degraded and easily recycled options. Enterprises should package the products in a reasonable manner to reduce the overuse of packaging materials and reduce the generation of packaging wastes. Unless properly managed, solid waste such as chemical containers, cardboard box have a potential to cause serious environmental and health impacts. It can lead to surface and groundwater contamination, land pollution and air quality deterioration[8]. Coal dust from the coal used in coal fired boiler and litter scattered by wind are responsible for deterioration of air quality in the vicinity of disposal sites.

iv. Energy

The increasing demand for the energy to power industry, however, is also producing unwanted effects, including higher energy prices, increased air pollution and higher emissions of greenhouse gases linked to climate change. To protect both economic growth and environmental values, we need to rapidly increase energy efficiency and deploy less carbon-intensive energy sources [7]. Characterizing the local industry it covers an extremely diverse range of activities. In 2000, industry was responsible for 30% of the greenhouse gas (GHG) emissions and consumed 35% of the country's primary energy. Improving industrial energy efficiency and reducing energy-related GHG emissions can be accomplished through technological improvements as well as changes in the structure of the overall industrial sector (in reaction to economic and environmental drivers).

Coal among the fossil fuels used for heating in the boiler, sanitation that is the cleaning of tanks. Beverage processes are relatively intensive users of both electrical and thermal energy [10]. Thermal energy is used to raise steam in boilers, which is used largely for sanitation and water purification in the, and in the cleaning of bottles. The process refrigeration system is typically the largest single consumer of electrical energy, but the, bottling hall, and wastewater treatment plant can account for substantial electricity demand.

Currently the boiler has no measures which have been put in place to try and improve the efficiency of the boilers, that is the boilers have no economizers there is no use of the condensate recovery system which contributes to large consumption of coal.

The key stages and process in carrying out CP are given in Table 1.

TABLE 1

CLEANER PRODUCTION STAGES [1]

PHASE	STAGES
I: Planning and organization	1. Obtain management commitment 2. Establish a project team 3. Develop policy, objectives and targets 4. Plan the Cleaner Production assessment
II: Pre-assessment (qualitative review)	5. Company description and flow chart 6. Walk-through inspection 7. Establish a focus
III: Assessment (quantitative review)	8. Collection of quantitative data 9. Material balance 10. Identify Cleaner Production opportunities 11. Record and sort options

IV. Research Design

The researcher made some plant tours to the case study organization. The walk through inspection helped to observe other process involved in the beverage manufacturing hence allowing a chance to identify areas were cleaner production could be implemented and to discuss with the people involved in the process of manufacture. The researcher reviewed the company's processes and policies to see where cleaner production was being practiced and established gaps which required CP redress.

V. Case Study Overview

DrinkCo Beverages produces bottled purified water, flavored drinks and canned juices. The company also, produces bottled and canned drinks', as part of manufacturing processes, water, carbon dioxide, sugar and other additives are involved. Water is a major component, making up to 50-70% of the drinks. Besides being a major component, water is also crucial in the cooling process during various manufacturing. Water is used for dilution, dissolving of the sugars, washing the bottles and cleaning of the floors. The process of manufacturing involves clarifying of water, filtering, mixing, carbonating and filling.

The firm operates two beverages and one water bottling lines. The water bottling machine is also used for bottling fruit range of products. The need to increase productivity, maintain consistent quality of packaging material and guarantee total product quality of its products led to the organization acquiring a pre-form making machine and two blow molders.

The plant is divided into the following branches of specialisation

- Water Treatment,
- Manufacturing Services,
- Packaging Operations,
- Warehouse,
- Engineering Quality Assurance

A. Manufacturing process

The major manufacturing processes at this plant are summarized by Fig 1 shown below.

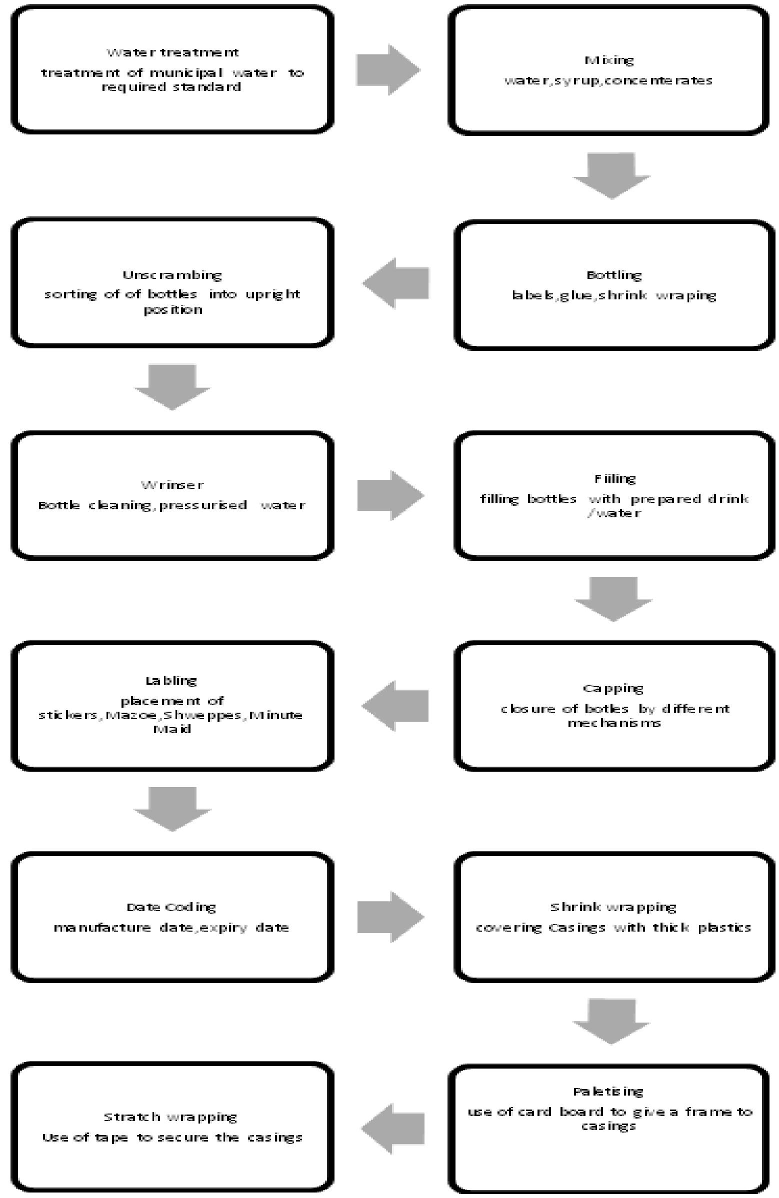

Fig 1.Manufacturing process sequence

B .Pre-assessment

The objective of the pre-assessment was to obtain an overview of the company's production and environmental aspects. Production processes are represented by a flow chart showing inputs, outputs and environmental problem areas. Qualitative review is done to assist the Assessment and Evaluation stages of the Cleaner Production.

C.CP Assessment

A detailed site inspection was performed at this step. During this task, processes were analyzed in detail to determine the inputs and outputs to be included in the mass

balances which would be the basis for CP opportunities evaluation. The evaluation guidelines are as follows:
On-site inspection activities
-Identify all wastewater discharges including leaks and spills.
-Monitor the process unit operations to identify unmeasured or undocumented releases of products and wastes.
-Make necessary measurements to identify flow rates of specific discharge sources.
-Make necessary experiments to characterize wastewater sources where there are obvious CP opportunities or high pollution loads to environment.
- Interview the operators in the targeted drink manufacturing processing areas to identify operating parameters, wastewater generation and spill reduction opportunities.
- Evaluate the general conditions of the processing equipment.
-Examine housekeeping practices throughout the facility.
-Check for spillage and leaks at the equipment
-Check waste storage area for proper waste segregation.

D.Environmental aspects

Liquid effluent: The company generates a warm, liquid effluent stream containing fruit juices, acids constituents and cleaning and sanitizing agents such as Metabisuphite and Caustic Soda used in cleaning of floors and product tanks. The quantity of effluent discharged per month is 730,000 L. The company is not connected to a wastewater treatment plant and therefore discharges treated effluent directly to a treatment site close to the plant were the pH levels of the water is reduced .

Emissions to air: Emissions to air principally result from the combustion of fossil fuels in the boiler for steam generation. Pollutants emitted include NOx, CO, CO_2, sugar dust and coal dust.

Solid wastes: Current operating practices generate a monthly average of 1420kg of solid waste comprising of ash, plastic containers and cardboard boxes and a little contribution from the electronic waste. By far the largest proportion of the company's solid waste stream is of packaging materials comprising, particularly the cardboard containers used to package drinks. Approximately 1200 containers are lost as waste per month, which represents approximately 10% of the total number of drinks ready for sale. Paper wastes are re-used off site wherever possible and reject glass bottles are also recycled off site.

Energy: The company generates its own steam in an on-site boiler for heating and processing, and other energy needs are met using electricity.

E. Material balance

The purpose of undertaking a material balance is to account for the consumption of raw materials and services that are consumed by the process, and the losses, wastes and emissions resulting from the process. A material balance is based on the principle of 'what comes into a plant or process must equal what comes out'.

Some of the data used in the assessment were estimates calculated from the aggregated figures basing on the capacity of unit processes and usage while some of the data were calculated after taking measurements. The data collected was an average of the half year operation of the year from June 2013 to December 2013

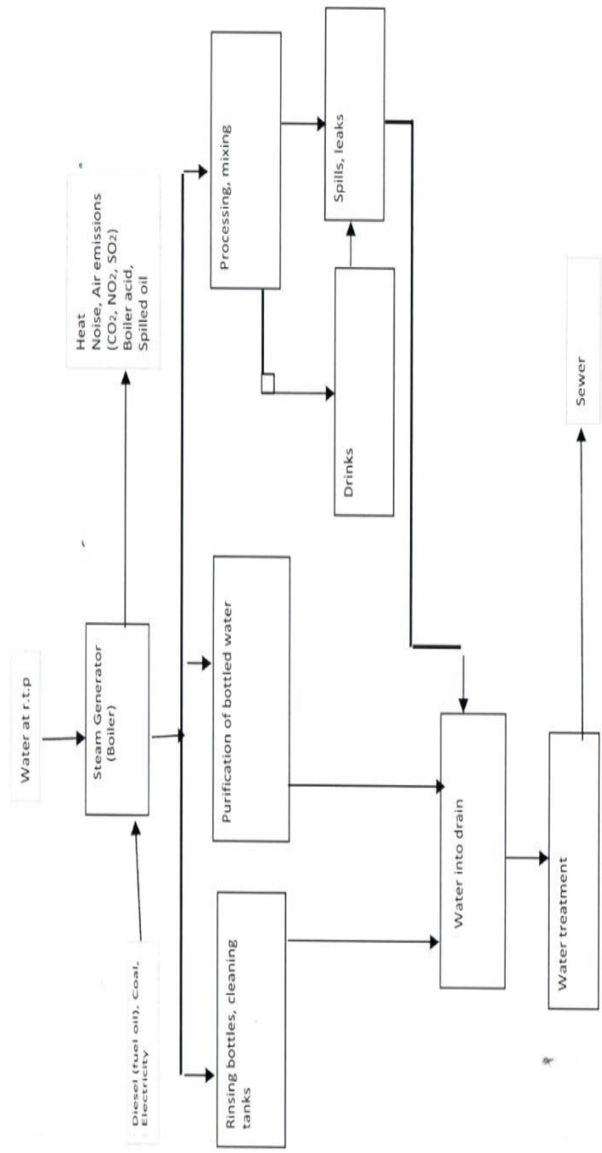

Fig 2.Steam generation flow process

Steam: Steam flow is shown in Fig 2 above and the input output is given by the Table 2 below

TABLE 2

STEAM PROCESS INPUT/OUTPUT

Inputs		**Outputs**	
Diesel	50L/hr~800L	Heat	2000.27 GJ
fuel oil	20L	Noise,	not quantified
Coal	0.013kg/L	Air emissions CO_2,SO_2	not quantified
Electricity	5000kwh		
Water at r.t.p	758000L		

Compressed air: generation and usage system is given by Fig 3 below.

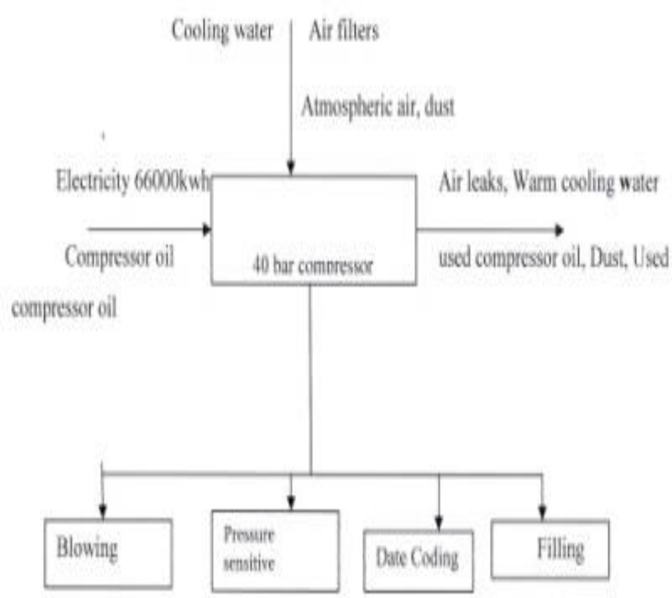

Fig 3.Compressed air process

Water treatment : process is also given by Fig 4 below and Table 3

TABLE 2

WATER TREATMENT PROCESS INPUT/OUTPUT

Inputs		**Outputs**	
Chlorine	200kg	Chlorine Spills	500g
Electricity	36000kwh	Lime	not quantified
Municipal water	7 400 000L	Treated water	7 400 000L
Aluminum Sulphate	25kg		

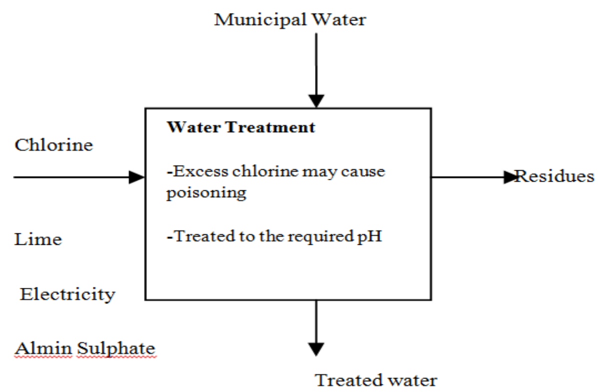

Fig 4.Water treatment process

The water is pre-treated on-site to meet product quality requirements before being used in the manufacturing process. The process of water treatment can be divided into two dies; a softened die produced softening water for bottle washing and for vapour production. The other produced treated water or (fresh water). This process is fed by municipal water.
The water input volume is measured by a flow meter. Then this water is stored in tanks to avoid any risk of water miss. For the production line of treated water, stored municipal water is pumped to the sand filter; a coagulation/flocculation can take place on line by adding aluminum sulfate according to the quality of municipal water. Then water passes through two decarbonator filters before stored. As this water is intended for the manufacture of simple and finished syrup, it must undergo a treatment by activated carbon with of two carbon filters.

Mixing of ingredients: Raw sugar is dissolved in treated water. Sugar is dissolved in the sugar dissolving unit where it is stirred through the use of electric motor, when completely dissolved the solution is mixed with concentrates or pure juices depending on the type and flavor.

TABLE 4

MIXING INPUTS/OUTPUTS TABLE

Inputs		**Outputs**	
Sucrose	0,027kgs/L	Noise approx.	76 dB (A)
Electricity	52000kwh	Flavoured drink	6 757 800L
Grease	20kg's	Spills	200L
Concentrates	0.0085kg/L		
Treated water	6 758 000L		

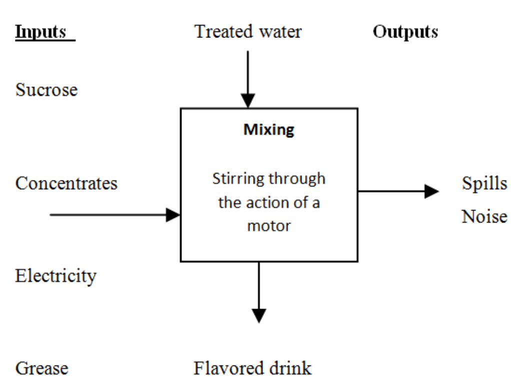

Fig 5.Ingredient mixing

Unscrambling: This is the sorting out of the different containers preparing them for the filling process. The bottles are removed from a container and are placed on the production line. It involves ordering of the disordered bottles, the random bottles are tided and set in a good position to the conveyor belt. Disordered bottles are carried out into a storing bottle section with the help of a rotating disk. The bottles are ordered into a mouth up position and conveyed to the next by a conveying system.

Rinsing: It involves the cleaning of the bottles using the highly pressurized water. Hot sanitation is used which involves the use of warm water as shown by Table 5 and Fig 6 below. Besides the cleaning of the bottles the process also involve the cleaning of the tanks during product change. Caustic Soda ($NaCO_3$)is used the cleaning of the tanks which is of great risk to the health of employees if not used as required in Product Change which is done on a daily basis during the early hours.

TABLE 5

RINSING INPUT/OUTPUT

Input		Output	
Water	320 000L	Heat	
Steam		water spills	3 200L
Electricity	42000kwh	Dirty water	316 800L
Bottles	118 800	Clean bottles	118800

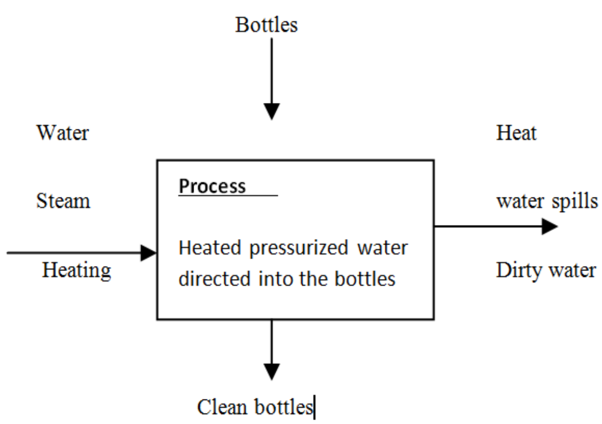

Fig 6.Container rinsing

Container filling: The process involves the filling of the bottles, with the juices or beverage. The juice is pumped out of the tanks and allowed to fill the bottle through valves. The bottles are held in position by a wire on the bottle neck. The filing takes place in the different sizes of containers 500ml, 1L PET, 340 ml cans. Capacity of the filler ranges around 5L per minute per filling valve depending on the present conditions of this machine as shown below.

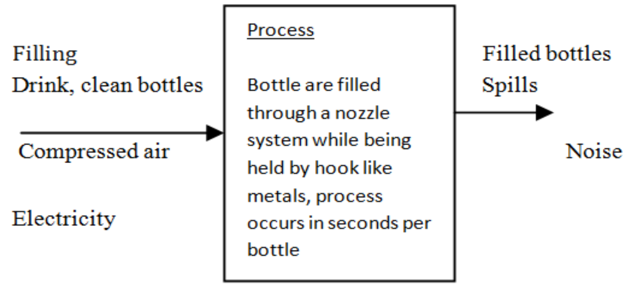

Fig 7.Filling process

TABLE 6

CONTAINER FILING INPUT /OUTPUT

Inputs		outputs	
Drink	675 800L	Filled bottles	117612
clean bottles	118 800L	Spills	6758L
Compressed air	not quantified	Noise	approx 95db(A)
Electricity	30 000kwh		

Capping: This is where closure of the filled bottles occurs. Bottles are brought by a conveyer system where each bottle is sealed. Depending on the design of the bottle different capping methods are used

Labeling: The process involves the use of glue, designed papers with the flavors written on them. The papers are stuck around the bottle using hot glue. The bottle containers are brought by a conveyor system a strip of the designed paper is unwrapped from the roll .Glue coming from a nozzle like structure is directed in circular motion to bottle were is used to stick the paper on the bottle

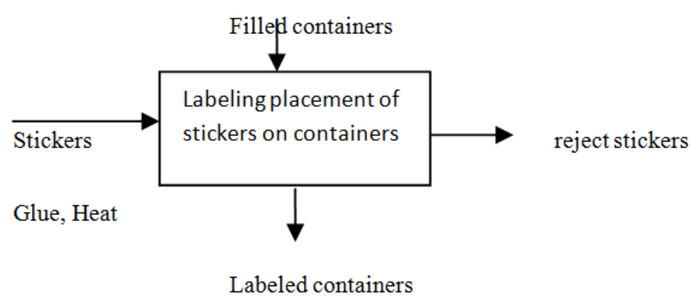

Fig 8.Labeling process

TABLE 7

LABELING INPUT/OUTPUT

Input		Output	
Stickers	118692	Reject stickers	1080
Glue	not quantified	Labeled containers	117612
Heat	not quantified		
Filled containers	117612		

Date Coding: The labeled bottles are directed to date coding machine, the bottles are stamped on the bottle neck using ink. The manufacturing date and expiry dare are stamped onto the bottle neck .For products such as the Minute

Maid the dates are placed on the cap. The permanent ink immediately dries once stamped on the bottle due to the warm environment created during the operation of the machine.

Shrink wrapping: The filled bottles are arranged in sets of six's and twenty-four's depending on the beverage type, for the 2 lt, 340ml they are wrapped in set of six, fruit and mineral water wrapped in 24's The sets are then wrapped in a plastic set of heated of elements are then used to shrink the 'casing'. The plastic then becomes tightening on the bottles. Great amount of heat is dissipated from the shrink wrapping machine such that there is need for an insulation measure to be put in place.

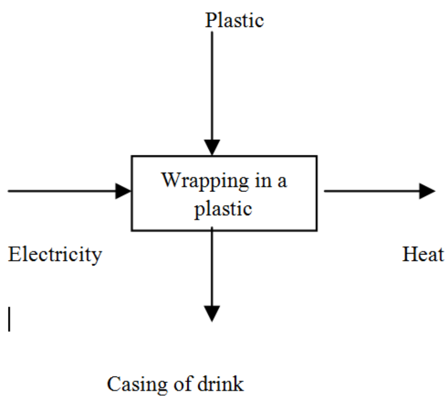

Fig 9.Wrapping process

VI. CLEANER PRODUCTIONS OPTIONS

Economic, technical and environmental evaluations were performed so as to select the best option for the cleaner production at the site. Ideally all unit operations should have been selected as a target for cleaner production but with the past experience it is common for Cleaner Production assessments to focus on those processes that:

- generate a large quantity of waste and emissions;
- need a lot of energy and raw material
- use or produce hazardous chemicals and materials;
- entail a high financial loss;
- have numerous obvious Cleaner Production benefits

Typical sources of problems at the site

Solid waste	:	plastic bottles
Soil pollution	:	Spilled waste oil
		Dumped waste oil
Noise	*:*	Engines and compressors
		Bottling hall
Air emissions	:	Combustion gases from boilers

Occupational health and safety problems:

- Noise in the bottling hall
- Handling of caustic soda

***Water treatment*:** Volumes of water were lost in this first stage, water spills from the over spilling tanks .The tank were lately closed during other shifts of production hence resulting in the water wastage. Chlorine spills were simply allowed to be washed away with the water to the nearby grass hence killing the grass. Periodic cleaning of tanks resulted in the water being directed straight into the drains.

Mixing: The process produced sugar dust while the sugar was poured to the water; generally great economic losses were due to incorrect mixtures that were simply directed into the drain leading to a near water treatment site. Leaking solution and wrongly prepared solution if allowed to flow freely it may find itself infiltrating into the water sources close by this may result in an undesirable change in the water quality due to different pH levels and salts .Such an action led to the losses of the ingredients such as sugar and the concentrated juices. Energy used by the stirrer is wasted; no recovery measure can be implemented to recover such an energy loss. Analyzing closely the process it affects the fuel wasted by the forklifts in carrying the sugar the stir, syrup room.

Rinsing: Nozzles used in the process were a contributor to the water losses, highly pressurized water spills were created in the process. Water used in rinsing was simply discharged into the drain; no efforts of reclaiming the water were currently underway. A lot of water was used during this process and warm water was not recovered hence increased the time and heat energy required to heat the water causing bowing down to cost associated with the boiler. Wastewater containing dirt as a result of spills when cleaning the containers went straight into the drain.

Wastewater and energy :During the study it was discovered that no condensate was returned to the boiler for re-heating. In the rinsing process, steam was directly used in heating water in steam/water mixers and was eventually discharged into the drainage system. All the steam except that lost due to leaks turned back into water and discharged into the wastewater treatment plant. Some of the pipes were not insulated. Steam leakage points were also noted. A total number of 4 steam leakage points were noticed. The boiler had no economizer or any mechanisms to reduce the consumption of coal.

Filling, Labeler, Shrink rapper Palletising: Spills mainly due to incorrect positioning of bottle containers during the filing process were measured .As a result of poor maintenance of the filling machine the solution in some instances is directed away from the opening of the bottles. The shrink wrapper consumes much of the electrical energy. Its operation of 22hours daily, simply because the elements on the wrapper require more time to heat up contributes to its large consumption of energy. Air compressors are often very noisy, and can be a nuisance for noise sensitive receptors in some circumstances. Since the air compressor is water cooled, water consumption is quite high. Small holes in the compressed air system (pipes, valves etc.), result in the loss of a large amount of compressed air continuously. This results in a waste of electricity because the compressor has to run more than is necessary .Card board left a shift of production is not reconsidered for the next shift it is simply discarded into the bins.

Since the objectives of study carried out involved minimizing waste, energy consumption the focus was selected on basis of the pollution and energy consumption. Using Berkel weighing method different process and stages were going to be analyzed to establish a focus of control . The different processes were ranked on basis of their level of energy consumption and pollution as shown by Table 8.

TABLE 8

OPTION RANKING

Input	Processes	Output	Rank
Steam	Rinsing	Steam leaks, condensing to flow as water	7
Water	Rinsing	Spills, dirt water with solid particles	5
Compressed air	Filling	Leaks, air in filled plastic bottles	7
Stickers	Labeling	Rejects, stuck on containers	5
Plastic	Shrinking, wrapping and paletising	Off cut, customers throw away plastic	5

Steam leakage: Steam leaks should be repaired as soon as possible when identified

Utilization of condensate: Steam condensate from the heater exchangers and by-products machine should be returned to the boiler. Utilization of the condensate will help reduce the amount of energy required to heat the water to produce the required steam. Condensate is a valuable resource and even the recovery of small quantities is often economically justifiable. The discharge from a single steam trap is often worth recovering. Unrecovered condensate is replaced by cold make-up water with additional costs of water treatment and fuel to heat the water from a lower temperature

Oil handling :It is very important to avoid oil spills, and if they occur, they need to be cleaned up properly. Oil spilling can cause serious pollution of soil and water. One liter of oil contaminates 1 000 000m^3 of water, rendering it unfit for drinking.

TABLE 9

OPTIONS RELATED TO EQUIPMENT RINSING

Type of prevention Practice	Typical low/no cost examples	Typical medium/high cost examples
Product Modification	Install nozzles on hoses to increase the effectiveness of spraying while decreasing water use.	Reduce the pumping cost by optimum pipe sizing since the power used to overcome the static head varies linearly with flow Replace the steel pipes with pvc(low coefficient of friction)
Technology Modification	Replacing the star-delta connection with a variable speed on the motor as is saves more energy	Monitoring the flow of the concentration mixture of the solution. Placing meters that measure density, temperature and concentrates of individual ingredients.
Good Housekeeping	Spot apply solvents instead of pouring; this helps avoid spills and stops excessive chemical use Turn off water between batches or while product change.	
On Site Recycling	use rinse water from the final stage of production for cleaning floors	

Labeling: Glue and labeled paper should not be used for labeling the plastic containers; stickers should be used for labeling since this reduces the loss of the glue and the heat required to heat the glue hence reducing the electricity consumption.

Filling: Shutting the system off when not in use and reducing the operating pressure of the system can also reduce the use of compressed air. A temperature-sensitive valve, ensuring the optimum cooling temperature and minimum use of water should regulate the consumption of cooling water. Furthermore, cooling water can be re-circulated via a cooling tower. Alternatively, the cooling water can be reused for other purposes such as cleaning, where hygiene requirements are low.

Plastic: There should be an initiative to bring back the empty containers to the plant so as to cater for the littering that is caused by these plastic bottles when disposed by the customer

Evaluation and feasibility: The suggested cleaner production options were evaluated in the different sectors that included technical, economic and environmental feasibility. The no or low cost options were suggested for implementation, housekeeping methods of cleaner production should be directly implemented without further investigation as they were rendered suitable for the site. The summary is given in the Table 10

TABLE 10

OPTION FEASIBILITY

Cleaner Production Option	**Expected feasibility**		
	Technical	**Economic**	**Environmental**
1.Utilization of condensate	Feasible	Reduces heating cost	Savings in energy and water
2.Using pressurized air for cleaning	Highly feasible	Saves water cost	Saves water
3.Replacing the star-delta connection with a variable speed on the motor, use of Variable Frequency Drives (VFDs) for use in pumps,	Feasible and practical	Moderate returns	Little or no effect
4. Placing meters that measure density, temperature and concentrates of individual ingredients.	Feasible	Low investment ,high returns	Reduction in chemicals discharged into the drain
5.Using rinse water from the final stage of production for cleaning floors	Feasible	Low cost	Savings in water
6.Using stickers for labeling	Feasible and practical	Eliminates glue costs	Savings in energy
7.Buying back the plastic containers	Highly feasible	Legal fines	Eliminates littering
8.Section metering	Feasible	Low returns	Little or no effect

VII. RESEARCH RECOMMENDATIONS

A. Option One: Utilization of condensate

Any process that allows energy contained in Steam condensate to go unutilized, is losing money in terms of fuel costs. Steam condenses to water at saturated temperature and so, depending on the pressure during condensation, the temperature of water may be 100 ^{o}C or more. Heat content in condensate is about 20% of the fuel energy burnt in the boiler. This is usable heat energy; it would be waste of money and resources.

B. Integrated assessment

In terms of environment protection, all options reduce pollutant discharge and they are friendly to the environment. Among them, option 1 is the best choice since it has the largest amount of reduced pollutants. In terms of economic benefits, each of the eight options in Table 10 has strong points and can provide significant benefits but only from three we managed to make an economic analysis. In general, the eight options all satisfy the comprehensive requirements of technology, economy and environment. However, option four is not currently recommended for implementation because new equipment and worker training are needed and the investment is relatively high. Based on the systemic characterization and analysis, all the options except 4 were combined into an integrated cleaner production system, which was recommended for implementation. Compared with individual option implementation, such an integrated CP system will generate more benefits, such as save more water and energy, and reduce more wastes. At the same time, the productivity and health and safety will be improved and more economic profits will be obtained.

C. Implementation of selected options

As for other investment projects, the implementation of Cleaner Production options involves modifications to operating procedures and/or processes and may require new equipment. The organization should, therefore, follow the same procedures as it uses for implementation of any other company projects. However, special attention should be paid to the need for training staff. The project could be a failure if not backed up by adequately trained employees. Training needs should have been identified during the technical evaluation.

Proposed framework for plastic bottles is as given in Fig 10 below , while the one for water usage and recovery is given by Fig 11 as shown.

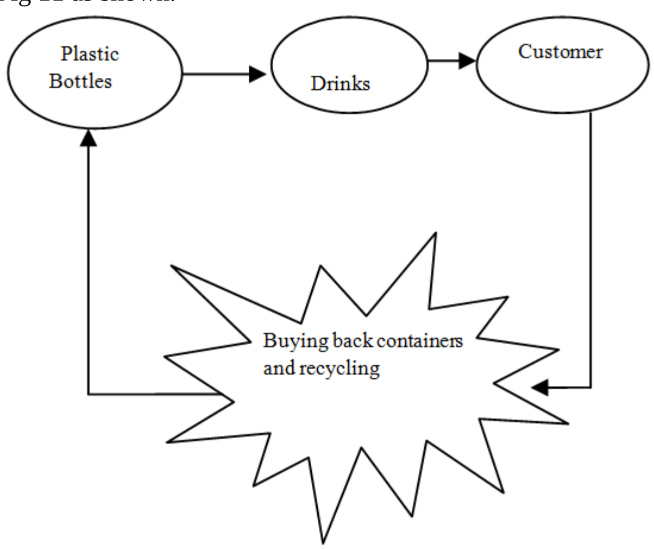

Fig 10. Plastic bottle re-cycling

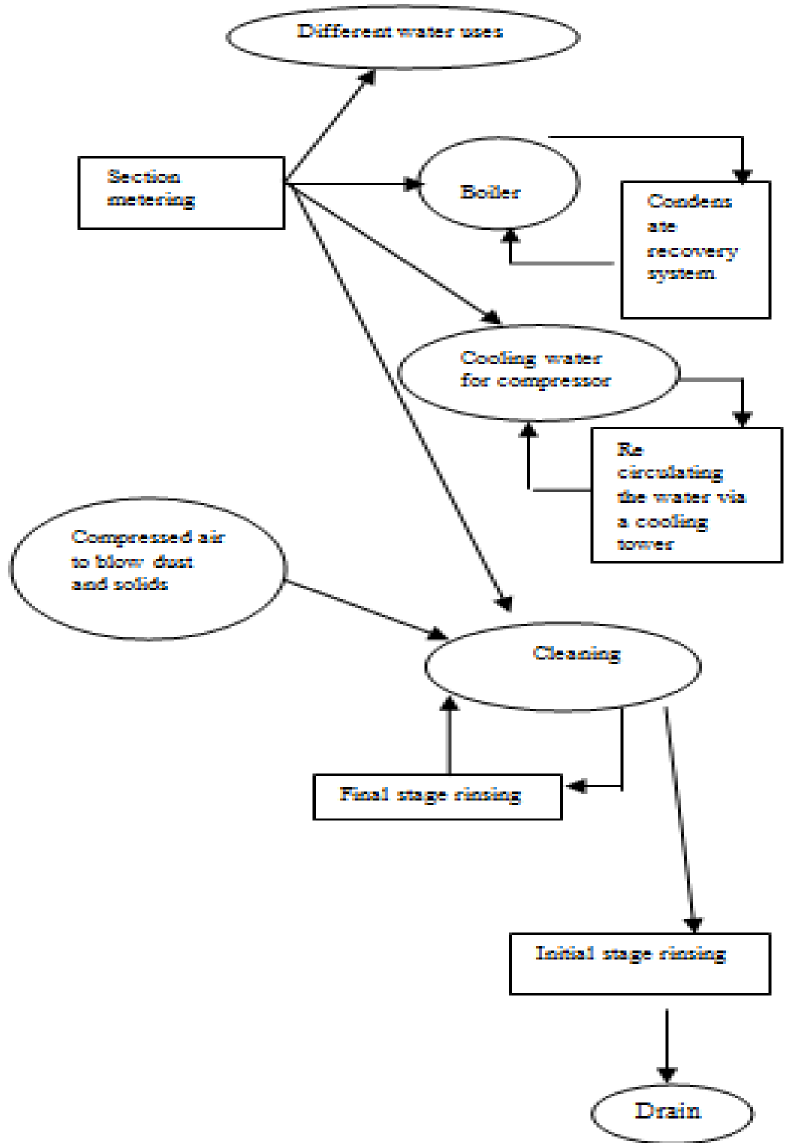

Fig 11.Water re-cycling system

VIII. CONCLUSION

To improve the resource efficiency, reduction in waste water and to reduce losses of raw materials during beverage manufacture, an integrated system combined with a series of advanced cleaner production technologies was proposed in this study. After the consideration of environmental impacts and economic efficiency, seven cleaner production options integrated with various advanced technologies were proposed. For option seven a further study that is beyond the grounds of this project have to be conducted to see if a method in which the company can buy back the plastic containers. While summing up, it is heartening to note that cleaner production technologies exercises are not only desirable from the environmental point of view as a preemptive strategy, but also make good economic sense. As has been seen in many cases, such exercises have added to the bottom line by conserving resources like energy, raw materials and manpower, improving yield and reducing treatment/disposal costs.

IX. FURTHER RESEARCH

Cleaner Production options savings through reduced costs for raw materials, energy, waste treatment and regulatory compliance. The environmental benefits of Cleaner Production can be translated into market opportunities for 'greener' products. Further work can be done on energy management options available to beverages manufacturing firms as the company still uses a lot of coal, steam and grid electrical energy, the aspect which remains a source of system inefficiency.

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